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THE THEORY OF NUMBERS[1]

THERE is probably less difference between the methods of a physicist and a mathematician than is generally supposed. The most striking among them seems to me to be this, that the mathematician is in much more direct contact with reality. This may perhaps seem to you a paradox, since it is the physicist who deals with the subject-matter to which the epithet "real" is commonly applied. But a very little reflection will show that the "reality" of the physicist, whatever it may be (and it is extraordinarily difficult to say), has few or none of the attributes which common-sense instinctively marks as real. A chair may be a collection of whirling atoms, or an idea in the mind of God. It is not my business to suggest that one account of it is obviously more plausible than the other. Whatever the merits of either of them may be, neither draws its inspiration from the suggestions of common-sense.

Neither the philosophers, nor the physicists themselves, have ever put forward any very convincing account of what physical reality is, or of how the physicist passes, from the confused mass of fact or sensation with which he starts, to the construction of the objects which he classifies as real. We can not be said, therefore, to know what the subject-matter of physics is; but this need not prevent us from understanding the task which a physicist is trying to perform. That, clearly, is to correlate the incoherent body of facts confronting him with some definite and orderly scheme of abstract relations, the kind of scheme, in short, which he can borrow only from mathematics.

A mathematician, on the other hand, fortunately for him, is not concerned with this

[1] From the address of the president of the Section of Mathematics and Physics, given at the Hull meeting of the British Association for the Advancement of Science.

physical reality at all. It is impossible to prove, by mathematical reasoning, any proposition whatsoever concerning the physical world, and only a mathematical crank would be likely now to imagine it his function to do so. There is plainly one way only of ascertaining the facts of experience, and that is by observation. It is not the business of a mathematician to suggest one view of the universe or another, but merely to supply the physicists with a collection of abstract schemes, which it is for them to select from, and to adopt or discard at their pleasure.

The most obvious example is to be found in the science of geometry. Mathematicians have constructed a very large number of different systems of geometry, Euclidean or non-Euclidean, of one, two, three, or any number of dimensions. All these systems are of complete and equal validity. They embody the results of mathematicians' observations of *their* reality, a reality far more intense and far more rigid than the dubious and elusive reality of physics. The old-fashioned geometry of Euclid, the entertaining seven-point geometry of Veblen, the space-times of Minkowski and Einstein, are all absolutely and equally real. When a mathematician has constructed, or, to be more accurate, when he has observed them, his professional interest in the matter ends. It may be the seven-point geometry that fits the facts the best, for anything that mathematicians have to say. There may be three dimensions in this room and five next door. As a professional mathematician, I have no idea; I can only ask some competent physicist to instruct me in the facts.

The function of a mathematician, then, is simply to observe the facts about his own intricate system of reality, that astonishingly beautiful complex of logical relations which forms the subject-matter of his science, as if he were an explorer looking at a distant range of mountains, and to record the results of his observations in a series of maps, each of which is a branch of pure mathematics. Many of these maps have been completed, while in others, and these, naturally, are the most interesting, there are vast uncharted regions. Some, it seems, have some relevance to the structure of the physical world, while others have no such tangible application. Among them there is perhaps none quite so fascinating, with quite the same astonishing contrasts of sharp outline and mysterious shade, as that which constitutes the theory of numbers.

The number system of arithmetic is, as we know too well, not without its applications to the sensible world. The currency systems of Europe, for example, conform to it approximately; west of the Vistula, two and two make something approaching four. The practical applications of arithmetic, however, are tedious beyond words. One must probe a little deeper into the subject if one wishes to interest the ordinary man, whose taste in such matters is astonishingly correct, and who turns with joy from the routine of common life to anything strange and odd, like the fourth dimension, or imaginary time, or the theory of the representation of integers by sums of squares or cubes.

It is impossible for me to give you, in the time at my command, any general account of the problems of the theory of numbers, or of the progress that has been made towards their solution even during the last twenty years. I must adopt a much simpler method. I will merely state to you, with a few words of comment, three or four isolated questions, selected in a haphazard way. They are seemingly simple questions, and it is not necessary to be anything of a mathematician to understand them; and I have chosen them for no better reason than that I happen to be interested in them myself. There is no one of them to which I know the answer, nor, so far as I know, does any mathematician in the world; and there is no one of them, with one exception which I have included deliberately, the answer to which any one of us would not make almost any sacrifice to know.

1. *When is a number the sum of two cubes, and what is the number of its representations?* This is my first question, and first of all I will elucidate it by some examples. The numbers $2 = 1^3 + 1^3$ and $9 = 2^3 + 1^3$ are sums of two cubes, while 3 and 4 are not: it is exceptional for a number to be of this particular form. The number of cubes up to 1,000,000 is 100, and the number of numbers, up to this limit

and of the form required, can not exceed 10,000, one hundredth of the whole. The density of the distribution of such numbers tends to zero as the numbers tend to infinity. Is there, I am asking, any simple criterion by which such numbers can be distinguished?

Again, 2 and 9 are sums of two cubes, and can be expressed in this form in one way only. There are numbers so expressible in a variety of different ways. The least such number is 1729, which is $12^3 + 1^3$ and also $10^3 + 9^3$. It is more difficult to find a number with *three* representations; the least such number is $175{,}959{,}000 = 560^3 + 70^3 = 552^3 + 198^3 = 525^3 + 315^3$. One number at any rate is known with *four* representations, namely, 19×363510^3 (a number of 18 digits), but I am not prepared to assert that it is the least. No number has been calculated, so far as I know, with more than four, but theory, running ahead of computation, shows that numbers exist with five representations, or six, or any number.

A distinguished physicist has argued that the possible number of isotopes of an element is probably limited because, among the ninety or so elements at present under observation, there is none which has more isotopes than six. I dare not criticise a physicist in his own field; but the figures I have quoted may suggest to you that an arithmetical generalization, based on a corresponding volume of evidence, would be more than a little rash.

There are similar questions, of course, for squares, but the answers to these were found long ago by Euler and by Gauss, and belong to the classical mathematics. Suppose, for simplicity of statement, that the number in question is *prime*. Then, if it is of the form $4m + 1$, it is a sum of squares, and in one way only, while if it is of the form $4m + 3$ it is not so expressible; and this simple rule may readily be generalized so as to apply to numbers of any form. But there is no similar solution for our actual problem, nor, I need scarcely say, for the analogous problems for fourth, fifth or higher powers. The smallest number known to be expressible in two ways by two biquadrates is $635318657 = 158^4 + 59^4 = 134^4 + 133^4$; and I do not believe that any number is known expressible in three. Nor, to my knowledge, has the bare existence of such a number yet been proved. When we come to fifth powers, nothing is known at all. The field for future research is unlimited and practically untrodden.

2. I pass to another question, again about cubes, but of a somewhat different kind. *Is every large number* (every number, that is to say, from a definite point onwards) *the sum of five cubes?* This is another exceptionally difficult problem. It is known that every number, without exception, is the sum of nine cubes; two numbers, 23 (which is $2.2^3 + 7.1^3$) and 239, actually require so many. It seems that there are just fifteen numbers, the largest being 454, which need eight, and 121 numbers, the largest being 8042, which need seven; and the evidence suggests forcibly that the six-cube numbers also ultimately disappear. In a lecture which I delivered on this subject at Oxford I stated, on the authority of Dr. Ruckle, that there were two numbers, in the immediate neighborhood of 1,000,000, which could not be resolved into fewer cubes than six; but Dr. A. E. Western has refuted this assertion by resolving each of them into five, and is of opinion, I believe, that the six-cube numbers have disappeared entirely considerably before this point. It is conceivable that the five-cube numbers also disappear, but this, if it be so, is probably in depths where computation is helpless. The four-cube numbers must certainly persist for ever, for it is impossible that a number $9n + 4$ or $9n + 5$ should be the sum of three.

I need scarcely add that there is a similar problem for every higher power. For fourth powers the critical number is 16. There is no case, except the simple case of squares, in which the solution is in any sense complete. About the squares there is no mystery; every number is the sum of four squares, and there are infinitely many numbers which can not be expressed by fewer.

3. I will next raise the question *whether the number* $2^{127} - 1$ *is prime*. I said that I would include one question which does not interest me particularly; and I should like to explain to you the kind of reasons which damp down

my interest in this one. I do not know the answer, and I do not care greatly what it is.

The problem belongs to the theory of the so-called "perfect" numbers, which has exercised mathematicians since the times of the Greeks. A number is perfect if, like 6 or 28, it is the sum of all its divisors, unity included. Euclid proved that the number $2^m(2^{m+1} - 1)$ is perfect if the second factor is prime; and Euler, 2,000 years later, that all *even* perfect numbers are of Euclid's form. It is still unknown whether a perfect number can be odd.

It would obviously be most interesting to know generally in what circumstances a number $2^n - 1$ is prime. It is plain that this can be so only if n itself is prime, as otherwise the number has obvious factors; and the 137 of my question happens to be the least value of n for which the answer is still in doubt. You may perhaps be surprised that a question apparently so fascinating should fail to arouse me more.

It was asserted by Mersenne in 1644 that the only values of n, up to 257, for which $2^n - 1$ is prime are 2, 3, 5, 7, 13, 17, 19, 31, 67, 127, 257; and an enormous amount of labor has been expended on attempts to verify this assertion. There are no simple general tests by which the primality of a number chosen at random can be determined, and the amount of computation required in any particular case may be appalling. It has, however, been imagined that Mersenne perhaps knew something which later mathematicians have failed to rediscover. The idea is a little fantastic, but there is no doubt that, so long as the possibility remained, arithmeticians were justified in their determination to ascertain the facts at all costs. "The riddle as to how Mersenne's numbers were discovered remains unsolved," wrote Mr. Rouse Ball in 1891. Mersenne, he observes, was a good mathematician, but not an Euler or a Gauss, and he inclines to attribute the discovery to the exceptional genius of Fermat, the only mathematician of the age whom any one could suspect of being hundreds of years ahead of his time.

These speculations appear extremely fanciful now, for the bubble has at last been pricked. It seems now that Mersenne's assertion, so far from hiding unplumbed depths of mathematical profundity, was a conjecture based on inadequate empirical evidence, and a somewhat unhappy one at that. It is now known that there are at least four numbers about which Mersenne is definitely wrong; he should have included at any rate 61, 89 and 107, and he should have left out 67. The mistake as regards 61 and 67 was discovered so long ago as 1886, but could be explained with some plausibility, so long as it stood alone, as a merely clerical error. But when Mr. R. E. Powers, in 1911 and 1914, proved that Mersenne was also wrong about 89 and 107, this line of defence collapsed, and it ceased to be possible to take Mersenne's assertion seriously.

The fact may be summed up as follows. Mersenne makes fifty-five assertions, for the fifty-five primes from 2 to 257. Of these assertions forty are true, four false, and eleven still doubtful. Not a bad result, you may think; but there is more to be said. Of the forty correct assertions many, half at least, are trivial, either because the numbers in question are comparatively small, or because they possess quite small and easily detected divisors. The test cases are those in which the numbers are prime, or Mersenne asserts that they are so; there are only four of these cases which are difficult and in which the truth is known; and in these Mersenne is wrong in every case but one.

It seems to me, then, that we must regard Mersenne's assertion as exploded; and for my part it interests me no longer. If he is wrong about 89 and 107, I do not care greatly whether he is wrong about 137 as well, and I should regard the computations necessary to decide as very largely wasted. There are so many much more profitable calculations which a computer could undertake.

I hope that you will not infer that I regard the problem of perfect numbers as uninteresting in itself; that would be very far from the truth. There are at least two intensely interesting problems. The first is the old problem, which so many mathematicians have failed to solve, whether a perfect number can be odd. The second is whether the number of perfect

numbers is infinite or not. If we assume that all perfect numbers are even, we can state this problem in a still more arresting form. *Are there infinitely many primes of the form* $2^n - 1$? I find it difficult to imagine a problem more fascinatiing or more intricate than that. It is plain, though, that this is a question which computation can never decide, and it is very unlikely that it can ever give us any data of serious value. . . . .

There is a great deal of mathematics the purport of which is quite impossible for any amateur to grasp, and which, however beautiful and important it may be, must always remain the possession of a narrow circle of experts. It is the peculiarity of the theory of numbers that much of it could be published broadcast, and would win new readers for the *Daily Mail*. The positive integers do not lie, like the logical foundations of mathematics, in the scarcely visible distance, nor in the uncomfortably tangled foreground, like the immediate data of the physical world, but at a decent middle distance, where the outlines are clear and yet some element of mystery remains. There is no one so blind that he does not see them, and no one so sharp-sighted that his vision does not fail; they stand there a continual and inevitable challenge to the curiosity of every healthy mind. I have merely directed your attention for a moment to a few of the less immediately conspicuous features of the landscape, in the hope that I may sharpen your curiosity a little, and that some may feel tempted to walk a little nearer and take a closer view.

G. H. HARDY

WHITHER?[1]

I

WHETHER one enters a group of socially minded thinkers or a group of doctors in private conference or in public assembly, one soon becomes conscious of a restlessness regarding the profession of medicine. What does one think of membership in the American "Royal" College of Surgeons or Physicians, of medicine practiced under the ægis of a "group," of higher education for nurses, of chiropractors, of Christian Sciencers, of medical societies going to the public with their wares? Is the patient still the doctor's, or does he belong to a hospital? Should "industrial" medicine be developed? Should hospitals be standardized? Should the medical educational requirements of six years be lengthened to seven or eight or nine? Where ought one to stand on "state" medicine; should medicine have a portfolio in the cabinet; should clinical teachers be forbidden private practice? Should hospitals be open only to staffs or to all licentiates in medicine?

Are the answers to these problems really hard to find?

The medical profession has been caught in the swirl of the times. In the press of the moment it has forgotten its origins. Lost sight of are the circumstances, the principles and the ideas which in all times have made medicine what it is. Cause and effect are being mixed up. The present day shows too much of the form and too little of the spirit of that which has given the doctor his place and power.

II

It is no new discovery that the tyranny of a crowd is no better than the tyranny of an individual and that both lead to death. In spite of our cry that we are democratic we are almost exactly the reverse. We certainly dress alike; it has been said that we look alike; the corollary is that we think alike. Tersely put, we work in crowds and think in gangs and when applied to medicine we forget why anything smacking of such forms has prospered.

A case in point is offered by the diagnostic and operating "groups" in medicine which today infest us. Blinded by the success of one or two prototypes, medical men have concluded that their form accounts for their popularity. The fact is that none such has prospered—save as any business which is not bankrupt may be said to be prospering—except as the old substance of medical practice has been kept alive in the group by one or two dominating personalities. Without such vital souls there is left only a paper organization—all, it is safe to predict, that will survive when the present day medical or surgical leaders of these groups are gone.

[1] Remarks made at the banquet of the Ohio State Medical Association meeting, May 3, 1922.

A second case is offered by the specialists. Men formerly were driven into specialisms through professional or popular demand. A doctor peculiarly skillful of hand or mind had his day filled for him by those insistent that he do continuously the thing in which he excelled. The present day specialist is a self-anointed soul. He knows that to have a large view in medicine means hard work and broken hours; he sees an "opening" for a specialist, spends six weeks learning the necessary tricks and succumbs to the easiest way. It will be answered that specialists are needed to do the complicated things of blood analysis, bacteriological study and X-ray investigation. The truth is that these newer things have not become additions, as they should be, to the older and established methods of diagnosis and treatment but lazy-man substitutes for them—and poor ones. In the main, these "scientific" methods have not decreased error in diagnosis or broadened treatment. Chemical methods of blood analysis have not enlarged our knowledge of kidney disease; failures to obtain positive bacteriological findings have permitted patients to go without a diagnosis where an older generation of doctors would have judged correctly the nature of the disease from its signs and symptoms; while the ease of looking through a patient with X-rays has dulled the touch, the sight, the hearing and the judgment which made great our predecessors.

It is the common thing for our patients to be sent to a laboratory man, an X-ray specialist, a nose and throat surgeon, a skin doctor and a half dozen different types of special surgeons. It has even been proposed that we need a specialist to determine what medicine shall be given. But those engaged in these types of practice are beginning to realize its dangers. The dangers are to be met with another specialist—one who is to gather together the findings of all the doctors and tell the patient what he came a-seeking. He is to be known as an integrator. I sent an article proposing this scheme to a friend of mine with the marginal note that our colleagues were beginning to look for doctors once more.

I know a place where one can serve himself to a diagnosis as one serves himself to a meal in a cafeteria. One starts with a numbered card and buys himself at different counters and from different men a general examination, an investigation of the throat, an X-ray plate of the gall bladder, a dental overhauling, a surgical operation and a plaster cast for the foot. Each item carries its price which is punched on the ticket. What the scheme takes no account of is that the patient does not care whether he has Hirschsprung's disease, erythema nodosum or pseudo-hypertrophic muscular atrophy. What he is after is a plain statement of what is the matter with him, and whether he can be "cured" or not; also there is wanted a little appreciation of his state of mind and some understanding of the economic hardships of his family in the interim of being ill. The food counters do not carry these dishes.

It is a sin against the Holy Ghost to say that the profession is overorganized, but such it is. Organization springs from the desire of minorities to live in spite of majorities. As such, organizations give life, shelter and fellowship to the threatened and despised of the world. Their purposes accomplished, they tend toward reaction so that rarely have they merit after birth, when their powers of leadership because of rightness of cause, are supplanted by the powers of organization to impress their will. What looks like strength is merely a cramp—medically expressed, the cramp of death. Once "successful," Chapman's charge is correct: "All association, business or social, literary or artistic, religious or scientific, is opposed to any disrupting idea." How much in medicine the individual cowers to-day in the shadows of this mass mediocrity is innocently portrayed in a recent volume on civilization in the United States. Of thirty men who write freely of our politics, art and religion the one who speaks for medicine must "for obvious reasons" remain anonymous.

This is just a reversed way of saying that the present day doctor has sacrified his individuality—the thing through which alone he has gained his public standing historically or in the present. Never before has he affected a community through mass action, and it is safe to predict that through such he never—last-

ingly—will. He enters the public's life through an individual's need of him; and in the crises of life—birth, fear, despair and death. Disease may be objective but its effects are all subjective. Through his understanding of the individual in these circumstances has come the reward of individual trust; and it is this confidence multiplied which constitutes the public esteem in which the doctor lives. To think that such can be built up through massed professional activity is idle.

When will we get a secretary of medicine in the cabinet? Never through a lobby but when someone politically powerful transposes the personal faith he feels in his body physician into political action. We may get him any day that an occupant of the White House trusts adequately the mind and heart of his doctor. This is the manner of men. Not so long ago another follower of the "regular" school asked me why one of our intelligent citizens threw his whole energies into the cause of homeopathy. I ventured the easy answer that his family doctor was homeopathist, and more—that as a man this doctor was no mean personality.

III

If the medical profession has problems it is because it has either voluntarily relinquished what it should have held or done badly what others have done better. Each of these headings has subheadings of a legitimate and an illegitimate type. The picture of my old doctor friend jogging along in his buggy in the hours after midnight, responsive to a charity call registered through a telephone which he had himself installed in the home of his patient is all too rare. I inquired why he had not sent his younger colleague. He answered that he could not ask an assistant to rise in the night and work without material recompense. The young doctors do not nowadays follow the sick poor of our hospitals to their homes. The social service workers do this and the human aspects of the problems of disease are to-day more commonly touched by the educated nurse than by medicine's new generation. But if these things be so, is it any wonder that the sum total of patients which constitutes our public is becoming increasingly deaf to suggestions which spring from the medical profession and increasingly responsive to those emanating from social uplifters or economic and political reformers?

I venture to add that we do not know enough. For more than a decade now the non-medical psychologists have been able to tell us more of the rank of our mental defectives than we ourselves knew; the graduates of domestic science schools have known more of food values than ninety-nine of a hundred doctors; and laboratory technicians in X-ray work and the simplest biochemical tests have become the interpreters to the profession of the things which it should know itself. If the medical man still feels that *he* is set apart to teach these things, he must be securer in his knowledge of the fundamentals.

From an illegitimate side, the doctor's calling has been placed in parallel with the caricatures and fragments of medical thought represented in Christian Science, osteopathy and chiropractice. There has been much scramble to keep these things in their proper places through the political seesawing of legislative groups inclined to listen at one time to the doctors and at another to the toredoes. The answer should be simple. Why does the doctor ever acknowledge these as competitors? Have they a better knowledge of the principles of medicine and surgery? Or need there be envy that chicane so often pays better than honesty? It will be argued that the public does not know enough and that it must be protected. This has been the cry of autocrats since the stork ruled the frogs. What is at stake is the question of our fundamental faith in democracy. In brutal terms, our average fourteen-year-old intelligence is asked to decide whether it will learn or die. For myself, I have little faith in the moral or mental merits of a people which in law buttress the one with the virtue of jails and the other by a superimposed intelligence. The superiority of a people is to be measured by its ability to withstand temptation and not by the number of its prohibitory laws which makes a going-wrong impossible; nor is its superiority proclaimed by an absence of quack solutions but by its clearness of intellect which permits it to distinguish these from better ones.

Why the forcing of more health laws upon an unwilling humanity? Those who do not believe in vaccination, antitoxins and the purification of water and food supplies might, for a change, be permitted to die. If our Christianity needs to be invoked let us consider St. Luke. As physician and teacher he preached that "Now is salvation come nigh unto you." But with the truth uttered he left his audiences to make the final choice.

The medical profession will increase or lose its public power only as the collective expression of the people's faith in the individual doctors who touch them. To breed such faith the doctor must get again his old courage and cease to be the pussyfooter of our present day. What is wanted is not a strutting vanity, common enough, but a consciousness in the doctor of where he came from and where he is going. To do this he needs to learn again that he is a judge and obligated as such to get at evidence first hand. The profession of medicine is an openhanded one whose discoveries, practice and points of view are free and obtainable for the asking. Let the medical man then choose well whom he will visit and learn from. Let him discover what men actually do and not what others tell him they do. This holds true also for the evidence which he gathers from the printed page. In the hustle of our modern life the medical man has here fallen into the group of the common. He does not read originals any more and hardly reviews. The thing has become so attenuated that in his journals and text-books he is literally consuming reviews of reviews of reviews. As well may a man think to understand the psychology of sheep because he feeds on lamb stew.

The fundamental situation will not be changed in the space of a night. New viewpoints and idealism grow best in young soil. Whence our interest in the education of the new doctor. But medical education like all so-called university education has fallen into bad ways. There have been carried into it the false ideals of the kindergarten and grammar school. Education is conceived of, too much, as something that may be bought for and added to a son. And the present day university course does cost only four years and four thousand dollars of anybody's money. This idea must change. If there is a fundamental law under which we live it is that of Lamarck. Not through environment but through the degree of reaction on our part to that environment do we develop or atrophy.

But what is there in modern university education which develops the senses to observation, the mind to logic and the soul to understanding? The medical student is to-day lectured into coma—but the skill we are seeking can be acquired only by doing. Whence will come the man and the institution to teach again by the apprentice system? When will we see again, working students emulating masters?

What is so badly started in the universities and medical schools continues in the subsequent professional life. There is an eternal clamor for positions on hospital staffs, on boards of control, on faculties of medicine. As in political parties, groups of doctors are insiders or outsiders. What does it all matter and when will it be learned again that only the man counts and not the circumstance? Staff jobs, faculty places and positions of power are the husks of corn. Men collect jobs like political badges, recognizing in all too few instances that they are nothing but opportunities for work—and who uses them?

A doctor friend told me recently that he felt cramped in a hospital which housed only eight hundred beds. But Boerhaave changed all European medicine with but twelve; Corrigan rewrote the chapter on heart disease with but six and Külz whose work fills one third of all the tomes on diabetes had just two patients. Could any practitioner have less?

IV

Our modern medicine is tending in two directions, the one leading toward the ideals of the five-and-ten-cent store and administrative madness. This group talks of "selling" its ideas to the public. The other is recognizing that the collective skill and power and position of the medical group is only a composite of the piled-together abilities of the individual doctor and the reaction evoked from the individual patient. Our time represents a call to return to the fathers. The world is seeking, as of old,

doctors with a kindliness, a tolerance and large understanding, the skill of hand, the skill of mind and the resourcefulness of a past generation. Where are the successors of van Swieten, John Hunter and Benjamin Rush or, in more modern terms, of Neusser, Osler and Billings? The Greek world sank as it grew in democratic principle—not in the abstract principle of democracy but in the concrete expression of it which substituted for its earlier rulers, proficient in the arts and sciences, the ever increasing number of non-productive Athenian traders. Is the efficiency of modern medical practice riding to a similar fall? Let us be honest with ourselves. If medicine fails it can not be ascribed to our stars, for our time, as all ages before it, in the hour of sickness and death cries as did Jeremiah: "Is there no balm in Gilead; is there no physician there?"

MARTIN FISCHER

COLLEGE OF MEDICINE,
UNIVERSITY OF CINCINNATI

ALEXANDER SMITH

FROM Edinburgh, Scotland, his birthplace, comes the news of the death of Professor Alexander Smith, lately head of the chemistry department at Columbia University. While this termination of the long and insidious illness which clouded his latter days was not unexpected, his loss is a heavy one for chemistry.

His circle of influence was perhaps widest as a text-book writer. Someone has remarked that a pre-eminent elementary text-book in any science appears but once in a generation. In his generation, Alexander Smith's elementary text-books have been the pre-eminent ones in this country, and, in their various foreign translations, have become well known abroad. When Smith was president of the American Chemical Society in 1911, an after-dinner speaker referred in his remarks to Smith's clear and sparkling eye, which, as those who knew him will recollect, was a very conspicuous and characteristic feature of his. Now, the same two epithets, clear and sparkling, might very properly be applied to his text-books in part explanation of their unrivaled position in the text-book field.

Smith's teaching work in this country was begun at Wabash College, whence, in 1894, he went to Chicago, at which place his teaching methods were chiefly developed. He was intensely active here also in administrative work both within, and, as dean of the junior college of science, beyond his own department; but had still abundant energy in reserve to continue investigative work. The researches on sulfur and on vapor pressures, for which, in 1912, he was awarded the Keith Prize by the Royal Society of Edinburgh, will recur to the minds of most chemists. In 1911 he migrated to Columbia University as head of the department of chemistry, which he proceeded to reorganize very fundamentally, energizing progress with his overflowing vitality until forced by illness to desist.

Truly, his spark was a brilliant one, but all too short-lived.

ALAN W. C. MENZIES

SCIENTIFIC EVENTS

THE COST OF RESEARCH WORK

THE report of the British Scientific and Industrial Research Department for the year which ended on July 31 last has been published. According to an abstract in the London *Times*, it is divided into two sections, the first, which is signed by Lord Balfour, being the report of the committee of the Privy Council for Scientific and Industrial Research, and the second, signed by the administrative chairman, Sir William S. McCormick, that of the Advisory Council.

The first section is largely concerned with financial detail. The total expenditure of the department during the financial year was £525,584, made up of £273,193 from the Exchequer, £65,358 interest on the capital fund of one million for the formation of research associations, £86,355 from the same fund, and £100,677 from fees for tests and special investigations carried out for outside bodies, from the contributions of the shipbuilding industry for research in the Froude tank, and from repayments by the fighting services for research undertaken directly for them. Deducting the last item and also the grants from the million capital fund, the actual net expenditure of the

department from public funds amounted to £338,552, against £427,432 in the previous year.

For the current year this expenditure is estimated at £342,641—nearly £85,000 less than in 1920-21, though about £40,000 of the reduction is accounted for by the government decision that research work undertaken directly for the fighting services at the National Physical Laboratory shall be a charge on the votes of those departments and not on the research department's vote.

While the council deplore the necessity for this reduction of expenditure, with the consequent slowing down of the research program, they realize that the check is less injurious now than if it had come at a later stage, because a steady policy in the matter of research is more conducive to success than the provision of larger sums of money without the assurance of their continuance. They refer with special satisfaction to the report of the Geddes committee, which stated: "We are of opinion that the activities of this department have been minutely examined with a view to obtaining a reduction of expenditure, and we are unable to recommend any further reduction beyond what has been effected."

The second section of the report also deals with the question of expenditure, and its introduction contains short notes by the Advisory Council on each of the activities of the department, intended to show the necessity for their continuance. It goes on to discuss the present position and future prospects of the research associations connected with the department. Of these, twenty-four have now received licenses from the Board of Trade, and twenty-two are in active operation. In addition, three other industries have the possibility of forming such organizations under immediate consideration, and preliminary negotiations are taking place with several others. Several examples are given of the economies and improvements in practice that have resulted from the work of these associations.

The report proceeds to describe the work that has been done for national purposes, including the work of the coordinating research boards, the research undertaken in the various research institutions belonging to the department, and certain investigations undertaken for the department elsewhere. There is also a brief account of the development of research for other parts of the empire, reference being made to the Empire Cotton Growing Corporation, the Colonial Research Committee, and the West Indian Agricultural College, for the last of which temporary buildings and laboratories are being prepared in Trinidad.

Steady progress is reported in the direction of closer cooperation between the scientific work of the various government departments, represented on the coordination boards, and an increasing tendency is noted on the part of the service departments to enlist the cooperation of outside bodies and to arrange for the open publication of the results of their work, when these are of general scientific and industrial importance.

A general survey follows of the work of various institutions under the direct control of the department, including the National Physical Laboratory, the Geological Survey, the Fuel Research Board, the Deep and Hot Mines Research Committee, the Building Research Committee, the Food Investigation Board, and the Forest Products Research Board.

The last part of the report deals with certain independent institutions and specific researches which have been aided by the department, and with the grants made to individual research workers and students. As regards the latter, 544 applications for grants were considered, against 333 in the preceding year, and 280 awards were made, against 245. The bulk of the applications for the academic year 1922-23 have been received, and already it is clear that they will at least equal in number those received last year. The expenditure proposed under this head for 1922-23 is £50,000, against an estimate of £47,000 for the year ending on the thirtieth of September.

PEKING UNION MEDICAL COLLEGE

THE year 1921, the seventh of the work of the China Medical Board of the Rockefeller Foundation, was marked by the completion of the main buildings of the Peking Union Medical College, the only institution for which the China Medical Board has thus far assumed complete financial responsibility.

It is hoped, according to the report of Dr.

Roger S. Greene, the director, that it may serve as a model for other medical schools, not in the sense that it necessarily represents the ideal in all matters of organization and construction, nor that it is as yet complete in every respect as a few of the largest institutions in other countries may be said to be complete, but that it presents, in China, a demonstration more nearly adequate than any that has preceded it, of the essential elements of a modern medical school.

The college seeks to point the way by which the future system of Chinese medical education may be adapted as well as possible to the actual conditions in the country. If the hopes of its founders are realized, it will graduate a select group of leaders in medical education, in research, and in public health administration, and a larger number of useful practitioners of medicine and surgery.

The attempt to harmonize the exterior of the college buildings with the great architectural monuments of Peking may be regarded as typifying the hope that the Peking Union Medical College itself may in time become a true Chinese institution, and that through it Chinese scientists may succeed in adapting western medical science to the needs of their own country more effectively than foreigners can ever hope to do.

It is obvious that foreigners can play only a very limited part so far as giving actual medical service is concerned; while foreign-trained Chinese doctors and nurses, though they can be very useful in the initial stages, will always be few in number and at some disadvantage because the schools they have attended have not sought to equip them for meeting the special conditions, whether of climate or of social and economic organization, which prevail in China. Therefore the establishment of an institution to provide the requisite training on local soil was logically the first step in the program of the China Medical Board. The efforts of its officers during these first years have accordingly been largely devoted to the reorganization and equipment, on a satisfactory basis, of one such medical school, the Peking Union Medical College.

Since 1915 the college has been supported by annual contributions from the China Medical Board. The budget for the academic year 1921-1922 provides for a gross expenditure, on the school and hospital, of $1,418,989 Chinese silver currency. The local income from fees and hospital earnings is estimated at $219,383 Chinese currency. To cover the difference an appropriation of $600,000 United States currency has been provided.

Of a teaching staff of ninety at the end of 1921, forty-seven were Americans or Europeans and forty-three Chinese, the latter being for the most part men who had been students in the United States or Great Britain. In order to lessen the isolation of the staff from scientific progress in the west, provision has been made for visiting professorships under which, every year, one or two leading medical scientists of the United States or Europe are invited to spend from four months to a year in Peking.

In 1921 visiting professors included Dr. A. B. Macallum, of McGill University, in physiology, and Dr. Francis W. Peabody, of Harvard University, in medicine. In 1922 the visiting professors from the United States are: Dr. E. C. Dudley, professor of gynecology in Northwestern University, Chicago; Dr. Harry R. Slack, Jr., of Johns Hopkins Medical School, in charge of the department of otolaryngology; Dr. Donald D. Van Slyke, a member of the Rockefeller Institute for Medical Research, who is giving graduate instruction in the department of physiological chemistry, and Dr. Elliott G. Brackett, professor of orthopedic surgery, Harvard Medical School, and during the war director of military orthopedic surgery for the United States Army, who has conducted graduate courses and clinics.

LEGAL RESTRICTIONS ON TYPES OF BABCOCK GLASSWARE

A STATEMENT has been issued by the experiment station at Geneva setting forth the provisions of the amendment to the agricultural law enacted at the last session of the legislature relative to the kind of Babcock glassware that can be legally used for making butter fat tests of milk and cream where the test forms the basis of payment. Accurate glassware is essential for just payments, and milk dealers and

farmers in New York have been protected by law in the past against inaccurate glassware which would influence the butter fat test. New York was one of the first states in the Union to compel all glassware jobbers and manufacturers to submit their glassware to be tested for accuracy previous to its sale. Since 1900, the experiment station has tested all the Babcock glassware used in New York before it was offered for sale. All glassware meeting the requirements is marked S. B., or state branded, to show that it has ben tested and found correct.

The purpose of the amendment of the old law is to reduce errors in testing milk and cream for butter fat by the Babcock method by reducing the number of kinds of glassware that can be legally used in making the test. During 1921 the experiment station tested more than 39,000 test bottles and pipettes representing more than 24 distinct types. Many of these types, although accurately made, were so constructed as to lead to errors. Such glassware is now illegal. Only five types of glassware are now permitted by law. These are the usual 8 per cent. milk bottle, the 9-gram short and long cream bottles, the 18-gram long cream bottle, and the plain 17.6 cc. pipette. The New York law, which is now in force, is in accordance with the provisions of the United States Bureau of Standards.

Babcock glassware takes its name from Dr. S. M. Babcock, of the University of Wisconsin, who perfected the method of testing milk and cream for butter fat. The method is now used universally as a basis for payment to the farmer for his milk and cream.

THE CONFERENCE ON HIGHWAYS

INCREASING interest in the forthcoming conference on highway transport and highway engineering education, to be held by the Highway Education Board in Washington, from October 26 to 28, is reflected in replies to invitations from educators and men high in the councils of the automotive industry. It is estimated that at least three hundred regularly invited delegates will be present, with approximately half as many more in attendance who are concerned in the problems to be studied. The headquarters of the conference will be the New Willard Hotel.

Ten committees are now preparing reports for submission to the conference as a whole. They will function with an educational chairman directing the research of their respective committees. H. W. Leavitt, assistant professor of civil engineering, University of Maine, is educational chairman of the committee on "Required Elective Undergraduate Subjects in Highway Engineering." L. W. McIntyre, assistant professor of civil engineering, University of Pittsburgh, is educational chairman of the committee on "Required and Elective Undergraduate Subjects for Highway Transport Business and Engineering Positions." On the committee, "Subject Matter of Basic Required Undergraduate Course in Highway Engineering," L. E. Conrad, professor of civil engineering, Kansas State Agricultural College, will serve as educational chairman.

Other educational chairmen and their committees are: C. B. Breed, professor of civil engineering, Massachusetts Institute of Technology, "Subject Matter of Basic Undergraduate Course in Highway Transport"; C. C. Wiley, assistant professor of highway engineering, University of Illinois, "Subject Matter of Undergraduate Course in Highway Engineering Theory and Design"; C. A. Baughman, professor of civil engineering, Alabama Polytechnic Institute, "Subject Matter of Undergraduate Course in Highway Engineering Laboratory"; Charles S. Howe, president of the Case School of Applied Science, "Nature and Content of Supporting Non-Technical Courses in Economics and English"; H. C. Smith, assistant professor of highway engineering and highway transport, University of Michigan, "Graduate Work in Highway Engineering and Highway Transport"; C. C. Albright, professor of civil engineering, Purdue University, "Conferences or Short Courses on Highway Engineering and Highway Transport"; H. J. Hughes, dean Harvard Engineering School, "Teaching Highway Traffic Regulation and Safety."

Among the automotive officials who plan to attend are Alvan Macauley, president Packard

Motor Car Company; Robert H. Salmons, vice-president Selden Truck Corporation; E. M. Sternberg, Sterling Motor Truck Company; Roy D. Chapin, president Hudson Motor Car Company; A. J. Brosseau, president Mack Motor Car Company; H. S. Firestone, president Firestone Tire and Rubber Company; H. W. Alden, vice-president Timken-Detroit Axle Company; Clark A. Ward, president Ward Motor Vehicle Company.

THE AMERICAN PSYCHOLOGICAL ASSOCIATION

THE Cambridge meeting of the American Psychological Association will be held on December 27, 28 and 29. The sessions will be in Emerson Hall, Harvard University, and the official headquarters at the Hotel Bellevue in Boston.

Because of the increased pressure for places on the program, the program committee is extending the sessions to include the afternoon of the third day of the meetings. So far as possible papers of general and theoretical import will be placed in the sessions on Wednesday, December 27. The business meeting will be on Wednesday evening. The sessions of Thursday, December 28, will include a symposium arranged by Section I of the American Association for the Advancement of Science and the address of Professor Bott, retiring vice-president of Section I. The annual dinner of the association followed by the presidential address and smoker will be Thursday evening. Friday, December 29, will be devoted to sessions of the Section of Clinical Psychology. In the afternoon the session will be at the Boston Psychopathic Hospital at the invitation of Dr. Campbell and Dr. Wells.

Apparatus may be exhibited in the Psychological Laboratory in Emerson Hall. Members are asked to supervise the setting up of their apparatus and the repacking of it. Consignments should be shipped to Dr. C. C. Pratt, Emerson Hall, Cambridge, Mass. The treasurer is authorized to pay transportation charges on apparatus, charts, demonstrational devices and text materials which the members display.

A cordial invitation has been extended to members by Professor M. W. Calkins to visit Wellesley College; by Dr. W. E. Fernald to visit the Massachusetts State School for Feebleminded at Waverley; by Dr. Wm. Healy to visit the Judge Baker Foundation at 40 Court Street, Boston; and by Dr. O. H. Lundholm to visit McLean Hospital at Waverley. Arrangements for these visits will be made during the meeting. Dr. Campbell and Dr. Wells invite the members to examine the work at the Boston Psychopathic Hospital after the meeting at the hospital on December 29.

SCIENTIFIC NOTES AND NEWS

DR. ROBERT A. MILLIKAN, chairman of the board of the California Institute of Technology and director of the Norman Bridge Laboratory, has been appointed a member of the committee on intellectual cooperation of the League of Nations to succeed Dr. George E. Hale, who has resigned from the committee.

DR. LUDWIK SILBERSTEIN, mathematical physicist at the Eastman Kodak Company Research Laboratory, has been appointed a member of the Commission on Relativity of the International Astronomical Union.

DR. CHARLES B. DAVENPORT, director of the Station for Experimental Evolution and the Eugenics Record Office of the Carnegie Institution of Washington, left New York on the *Paris* for Europe on September 13. He planned to proceed to Brünn, Czechoslovakia, for the purpose of participating in the International Gregor Mendel Centenary on September 22, 1922, and from Brünn to go to Vienna to attend the meeting of the German Society of Geneticists from September 25 to 28. His next visit will be to Upsala, where he will confer with Dr. Herman B. Lundborg of the University of Sweden. From Sweden he will proceed to Norway for the purpose of paying a visit to Dr. Jon Alfred Mjoen, of the Winderen Laboratorium, Christiania, thence to Holland to visit Dr. Joh. Von Der Speck, Doldersche Weg. 60, Den Dolder. He will go to Belgium for the purpose of attending, as delegate of the Carnegie Institution of Washington and the Eugenics Research Association, the meetings of the International Commission of Eugenics.

These will be held from October 9 to 14. The next visit will be to Paris in the interests of the Third International Congress of Eugenics. In London, on October 24, he will lecture before the Eugenics Education Society on "Recent Work of the Eugenics Record Office." He will sail from England about October 25.

DR. HUGH S. CUMMING, surgeon general of the U. S. Public Health Service, sailed on October 5 for Europe to spend two weeks inspecting the government's sanitary stations abroad. While in France, General Cumming will also attend the convention at Paris which is to revise the international sanitary treaty of Rome, where he will present several amendments concerning international measures against typhus, the plague and cholera. He will attend, in addition, the meeting in Paris of the hygiene unit of the League of Nations.

DR. DAVID STARR JORDAN has sailed for Japan. He expects to return to Stanford University in December.

DR. H. CILENTO, of the Australian Health Department, recently arrived in America to study the methods used by the late General Gorgas in effecting sanitation in the Canal Zone.

DRS. LEON BLEUM, P. Bouin, Georges Weiss and L. M. Pautrier, of the University of Strasbourg, arrived in New York on October 2. They plan to make a study of American hospitals.

NEIL M. JUDD, curator of American archeology of the U. S. National Museum and director of the National Geographic Society's Pueblo Bonito Expedition, returned to Washington at the end of September after having completed the second season's exploration of the great ruin of Chaco Canyon, New Mexico.

EDWARD S. HANDY, ethnologist of the Bishop Museum of Hawaii, will leave Honolulu in December or January to take charge of an expedition to Tahiti and Moore, for which the museum has completed arrangements. The work is planned to supplement the investigations by members of the Bayard Dominick Expedition, who have been at work in the Marquesas and the Austral Islands during the past two years.

PROFESSOR ALBERT W. SMITH, formerly dean of Sibley College, Cornell University, and acting president of the university, has returned to Ithaca, where he is engaged in writing the biography of John Edson Sweet, first head of the mechanical engineering instruction at Cornell, and later president of the Straight Line Engine Company of Syracuse. Professor Smith retains his connection with the Kent Construction Company of Rutherford, New Jersey, as consulting engineer.

DR. WARREN D. SMITH, who has been for the past two years on leave of absence from the University of Oregon, in charge of the Division of Mines, Bureau of Science, Manila, P. I., has returned to the university to resume his work in geology and geography.

THE Norman Lockyer Observatory, Sidmouth, England, has elected Dr. Otto Klotz, chief astronomer and director of the Dominion Astronomical Observatory, Ottawa, an honorary overseas member.

HENRY E. SUMMERS has retired from active work as state entomologist of Iowa and professor of zoology in Iowa State College, positions to which he was appointed in 1898. He will live in Los Angeles, California.

MAYO DYER HERSEY, associate professor of the properties of matter in the department of physics of the Massachusetts Institute of Technology, has resigned to take a position as physicist in charge of the Physical Laboratory of the United States Bureau of Mines, Pittsburgh, Pa.

MR. BARRY J. ANSON has recently resigned his assistantship in the U. S. Bureau of Fisheries Biological Station, at Fairport, Iowa, to accept a Rockefeller Foundation medical fellowship paying $2,000. He is working at Harvard University.

MR. E. LEONARD GILL, of the Hancock Museum at Newcastle-on-Tyne, has been appointed assistant in the natural history department of the Royal Scottish Museum, Edinburgh.

WHEN the *Maud* was at Deering, Kotzebue Sound, Alaska, in order to land Captain Amundsen for his proposed airplane flight across the polar area, Dr. H. U. Sverdrup, in

charge of the scientific work of the Amundsen expedition, mailed magnetic records to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The expedition was able to reoccupy magnetic stations of 1920 and 1921 at Kain-ge-sken, Siberia.

THE Italian government has decided to restore to the German psychiatrist, Professor E. Kraepelin, his villa in Italy, which was confiscated during the war as enemy property.

DR. E. D. BALL, director of scientific work in the U. S. Department of Agriculture, and national president of Gamma Sigma Delta, the agricultural honor society, installed a chapter at the Pennsylvania State College on October 10. A local association has also been formed by members of the Society of Sigma Xi who reside in State College or vicinity, with Dr. F. D. Kern as president and Professor C. Emory Myers secretary-treasurer.

DR. HENRY H. DALE, director of the National Institute for Medical Research, London, gave a Hanna lecture at the Medical Library Auditorium in Cleveland on October 6.

DR. HARLOW SHAPLEY, director of the Harvard College Observatory, lectured at Mount Holyoke College on October 6 on "Measuring the Milky Way." The lecture is the first of a series of science lectures provided for by the Polly Hollingsworth fund for lectures on art, science and music.

PROFESSOR L. BAIRSTOW delivered a lecture to the Royal Aeronautical Society on October 5, on "The Work of S. P. Langley."

THE twenty-fifth annual Traill-Taylor Memorial Lecture of the Royal Photographic Society was delivered by Dr. R. S. Clay on October 10, on "The development of the photographic lens from the historical point of view."

FOLLOWING services which were held at his home, the body of Dr. William S. Halsted, late professor of surgery in the Johns Hopkins University, who died on September 7 at Johns Hopkins Hospital, was cremated on September 9, in pursuance of his wish. Drs. William H. Welch, Howard A. Kelly, William H. Howell, John J. Abel, William G. MacCallum, Harvey Cushing, Ira Remsen, Winford H. Smith, John Whitridge Williams and Judge Harlan were the honorary pallbearers, and Drs. John M. T. Finney, Joseph C. Bloodgood, Hugh H. Young, George J. Heuer, Samuel J. Crowe, Walter E. Dandy and Mont R. Reid were the active pallbearers.

DR. JOSEPH E. WINTERS, professor emeritus of the diseases of children at Cornell University Medical College in New York, died in Boston on October 4.

DR. INIGUES, professor of astronomy at the University of Madrid and formerly director of the Madrid Observatory, has died.

DR. WILLIAM HALSE RIVERS RIVERS, of St. John's College, Cambridge, author of works on ethnology, psychology and anthropology, who died on June 4, aged fifty-eight, bequeathed to St. John's College the portrait of himself by Shields, to the library of the college such of his books as the council of that college may choose; the balance of his books and pamphlets to the University of Cambridge, for the departments of psychology and ethnology as the librarians may select; and to his friend, Professor Grafton Elliot Smith, professor of anatomy in the University of London, all his MSS. and unpublished works as his own property, but requesting him to publish such portion as he might consider ought to be published, and he left to him £500 for defraying the costs of preparing and publishing these documents.

THE John Elliott Memorial Pathological and Bacteriological Laboratory at the Chester Royal Infirmary was opened on September 16 by Sir Humphrey Rolleston, K.C.B., M.D., president of the Royal College of Physicians of London. The laboratory has been fitted and equipped by public subscription in memory of the late Dr. John Elliott, honorary physician to the infirmary from 1895 to 1921.

PRESIDENT-EMERITUS PATTERSON, of the University of Kentucky, died at his residence on the campus on August 15, 1922, in his eighty-ninth year. After making a number of personal bequests he left his residuary estate to be reinvested by the Security Trust Company, of Lexington, and the interest compounded until it shall become large enough to yield an income of $35,000 or $40,000 a year, when the income

is to be used to maintain the William Andrew Patterson College of the University of Kentucky, the purpose of which shall be to train young men for diplomatic and consular service. President Patterson's library is to be given to the university on condition that it be kept intact and that the books be not allowed to go out of the room in which the library is kept. The will names as literary executors Dr. William B. Smith, of New Orleans, and Miss Mabel Pollitt, who are to examine correspondence and other writings and prepare and publish a biography.

A JOINT meeting of the Eastern and Western Divisions of the American Philosophical Association will be held in New York City on December 27, 28 and 29, at Union Theological Seminary. At this meeting Professor John Dewey will deliver the Paul Carus Lectures on the attempt to apply a theory of experience to certain metaphysical problems. The afternoon sessions will be largely devoted to the lectures by Professor Dewey, and the morning sessions to the reading and discussion of papers offered by members. Abstracts of papers should be in the hands of Professor G. A. Tawney, University of Cincinnati, Ohio, not later than November 10. On Wednesday and Thursday evenings, respectively, the smoker and annual dinner will be held, and at these times also addresses by the presidents will be delivered.

THE writer of "From an Oxford Note-Book" in *The Observatory,* who is always very much alive, writes in the last number as follows: "Those interested in handy reference works will be grateful to the compilers of *Who's Who* for producing a supplementary volume *Who was Who,* covering the period 1897-1916. The volume was intended to appear in 1916, but owing to the war its publication was delayed. It has now been produced, and can be put upon the reference-shelves. Since it consists chiefly of extracts from the volumes of the main publication, with dates of death added, its information can generally be trusted; but I notice that it contains a statement of the death in 1909 of Professor Turner, of Oxford. Now I much doubt the accuracy of this information. I have certainly not seen the actual face of the learned gentleman for many years; but I have heard him lecture, and (unless wireless has entered upon a new phase) I do not think he was very far away. Further investigation is, however, proceeding."

UNIVERSITY AND EDUCATIONAL NOTES

THE China Medical Board of the Rockefeller Foundation has given $125,000 each to Southeastern University at Nanking and Nankai College at Tientsin for science buildings and equipment. Southeastern University is a government institution, located at Nanking, the old southern capital of China. Nankai College, in the north, is a private institution receiving provincial aid.

THE *Journal* of the American Medical Association reports that the new Darling Building in the Medical School of Adelaide University, South Australia, was opened recently by Sir George Murray. It is to be devoted to the departments of the fundamental sciences in the faculty of medicine, as there has been inadequate accommodation for the teaching of anatomy, physiology and pathology. The family of the late Mr. John Darling contributed £15,000 towards the erection of the building.

DR. CHARLES RUSS RICHARDS, formerly dean and director of the College of Engineering of the University of Illinois, will be inaugurated as president of Lehigh University on October 14.

DR. HOWARD B. LEWIS, formerly associate professor of physiological chemistry at the University of Illinois, has accepted an appointment as professor and head of the department of physiological chemistry in the Medical School of the University of Michigan.

DR. LEON A. HAUSMAN, of Cornell University, has joined the staff of Rutgers College as instructor in zoology and research zoologist.

JOHN L. BUYS, instructor in entomology at Cornell University, has been appointed assistant professor of entomology at the University of Akron.

DR. A. D. HOWARD, until recently assistant in the Bureau of Fisheries with assignment to certain fresh-water mussel studies at the bio-

logical laboratory at Fairport, Iowa, has resigned to become assistant professor of zoology at the University of Southern California.

PROFESSOR T. J. TALBERT, superintendent of farmer's institutes and extension schools and leader of subject matter specialists, Division of Extension, Kansas State Agricultural College, has been appointed professor of horticulture and chairman of the department of horticulture at the University of Missouri.

DISCUSSION AND CORRESPONDENCE

THE PALEOPATHOLOGY OF THE PARASUCHIANS

STUDENTS of vertebrate paleontology have long been aware of the presence of curious knob-like eminences on the snouts of the Triassic crocodile-like, elongate reptiles which Huxley regarded as the Parasuchia, but are now known as the Phytosauria with an organization quite remote from that of the Crocodilia. No adequate explanation of these eminences has ever been given although the writer referred to one of them as a callus following a fracture; an interpretation from which he was dissuaded by Huene. Recently Dr. Case has written me about a very curious example of these eminences and Professor O. Abel of Vienna has discussed[1] in a very interesting manner the nature of all the eminences, regarding them as lesions following injuries received in combat, and as occurring more frequently in the male. The ensuing complexities of a taxonomic nature are startling, and if correct pathological disturbances will reduce a lot of scientific names to the limbo of useless terms.

But I am not at all sure that Abel is correct. His argument is from analogy only. He has given not one positive anatomical or pathological evidence to prove that the eminences are "Bissverletzungen," or lesions of a traumatic nature with often huge necrotic sinuses, if they are at all pathological. The weakness of Abel's argument consists in the fact that the eminences are always in the median line and are always fairly symmetrical, at least in all the examples known to me. So before Abel's conclusions are accepted and the taxonomy of the Phytosauria revised we must have definite proof that these eminences really are pathological in nature and not something else. They *may* be pathological lesions, but we do not *know* they are, and there are methods of determining this point within reasonable limits of certainty, and that is by a histological comparison of the bone from one of the eminences, with normal bone elsewhere on the snout.

We have sufficient knowledge of the histology of fossil bone through the studies of Kölliker, Seitz and Schaffer, whose work is reviewed in my forthcoming volume on "Paleopathology," and to which I have made a number of additions. From the standpoint of histology the bone tissue of ancient forms, and of modern fishes, consists largely of an osteoid tissue which in normal fossil bone has few, widely-scattered lacunæ, scant lamellæ and little or no evidences of an Haversian arrangement. In fossil pathologic bone, however, the lacunæ become more numerous, the lamellæ more prominent, and numerous concentric arrangements, recalling Haversian systems, are apparent. I have found this to be true in callosites of the Permian reptiles, in the Comanchic dinosaurs, in the Pleistocene cats, in pre-Columbian man and in the modern bison, so we may say the phenomena are universal. Foote has recorded a similar fact for the modern bull-frog, in a case of a fracture of the femur.

Until positive evidence of this kind is forthcoming Abel's conclusions must await acceptance. The matter is far too important for hasty judgment. The numerous fossil pathological lesions I have studied are so different from the symmetrical, median eminences seen in the Phytosauria that I hesitate to accept them as callosities. We usually find a lack of symmetry in pathological lesions, especially in those of a traumatic character.

ROY L. MOODIE

COLLEGE OF MEDICINE,
UNIVERSITY OF ILLINOIS

[1] O. Abel: Die Schnauzenverletzungen der Parasuchier und ihre biologische Bedeutung (mit 10 Textfiguren). *Paleontologische Zeitschrift*, Bd. V, Heft 1, Juni 1922, pp. 26-57.

MEASUREMENTS OF HUMAN CRANIA

TO THE EDITOR OF SCIENCE: For many years students of physical anthropology have been handicapped by the lack of reliable cranial measurements from the American area. The National Museum in Washington and several other museums contain rich collections of crania, but no satisfactory measurements of these have been published.

After some discussion of the situation with Dr. Aleš Hrdlička, curator of physical anthropology at the National Museum, and correspondence with the secretary of the Smithsonian Institution, a plan has finally been adopted by which the large collections in Washington will soon be made available. Measurements of the entire series of human crania will be made under Dr. Hrdlička's direction and published in the form of a catalog which will be issued in parts in the Proceedings of the U. S. National Museum. It is expected that several parts will be printed each year, the first being already in press.

It is to be hoped that other museums will now follow the lead, and that in this way the large mass of materials which they contain for the study of the physical anthropology of the American Indian will, in similar fashion, be made available for students.

ROLAND B. DIXON

HARVARD UNIVERSITY,
SEPTEMBER 15, 1922

BIBLIOGRAPHY AND RESEARCH

TO THE EDITOR OF SCIENCE: A clearer portrait of the "book sciences" than that in Mr. W. W. Bishop's "The Record of Science," I have never seen in the ten years that I have been engaged in library work.

Many of the thoughts expressed in Mr. Bishop's address have been uppermost in the minds of many of the directors of the laboratories of book science, if I may be permitted to borrow Mr. Bishop's phrase. Many of us have seen this college and that college, this large concern and that large industry, endowed with munificent funds for research. In 1920-1921 there appeared in our leading index to technical periodicals over 100 titles relating to research work. The National Research Council has published a second edition of "Research Laboratories in Industrial Establishments in the United States," listing some 526 industrial houses operating laboratories devoted to research in one form or another. The same institution later published a list of the sums invested in research fellowships and endowments. The total endowments and fellowships amounted to 565, representing, in round numbers, over $22,000,000.

Now Mr. Bishop has pointed out that bibliography is the *foundation* of research. Yet I fail to find any specified sum set aside for a well equipped laboratory of book sciences. I doubt if 50 per cent. of these 526 industrial concerns supporting laboratories own and operate respectable laboratories for research in facts, or as I choose to call these libraries, laboratories for "research fact-oring." In fact, I know of one organization that spent over $400,000 for a research laboratory and yet in its laboratory for research fact-oring, it did not invest one tenth of that amount.

Now, then, why not promote sentiment for the establishment of endowments for research laboratories in "fact-oring" and fellowships in book sciences?

K. C. WALKER

AN UNUSUAL SOLITAIRE GAME

DEAL at random 25 cards from a pack of 52 playing cards and arrange them in five complete poker hands any one of which may be a flush (such as any five hearts), a straight (such as 3, 4, 5, 6, 7, or Ace, K, Q, J, 10, not necessarily of one suit), or a full-house (three of one kind and two of another).

Various persons have tried this solitaire several hundred times and worked it without finding a single case of failure, occasionally after many attempts. It was believed that it would always succeed. After some reflection, the writer invented the following impossible deal:

Diamonds:	2, 7, Q.
Hearts:	3, 4, 9, Q, K.
Clubs:	1, 3, 5, 6, 7, 8, 10, J.
Spades:	1, 2, 4, 6, 8, 9, 10, J, K.

with exactly two of each kind, excepting the

single 5. Since there are not three of a kind, there can not be formed a full-house. But how are we to be certain that we can not make five flushes and straights with these 25 cards? We can not examine the more than 5,194 billions of ways of arranging the 25 cards into five sets of five each, not distinguishing the order of the cards in a set or the order of the sets. We shall resort to the following conclusive analysis:

Since there are only three diamonds, no one of them occurs in a flush, and they are too far apart for two of them to occur in a straight. Hence 2d, 7d, Qd occur in three separate straights.

First, let both 3h and 4h occur in a straight with 2d, and hence with 5c, the only 5. Since there is no 5 left to go in a straight with 3c or with 2s, there is a flush of clubs and a flush of spades. These with the three straights mentioned must exhaust the 25 cards. But Qh is too far from 2d or 7d to be in a straight with one of them, nor can it be in a straight with another queen, Qd, nor in a flush of clubs or spades.

Second, let either 3h or 4h be not in a straight with 2d, and hence not in another straight (since a new 5 is lacking). Thus either 3h or 4h lies in a flush, containing all our five hearts. Since 2s can not occur in a straight (5 lacking), there is a flush of spades. Hence we have these two flushes and the three straights containing 2d, 7d, Qd. But 7c can not occur in one of these five poker hands.

This completes the proof that the above 25 cards can not be arranged in five complete poker hands.

L. E. DICKSON

SCIENCE IN FICTION

TO THE EDITOR OF SCIENCE: I am getting up a little catalog of fiction on scientific themes and should like the help of SCIENCE readers. Such books belong mostly to four classes:

(1) Fantastic and futuristic fiction, such as Jules Verne's "Twenty Thousand Leagues Under the Sea" (submarine) or "A Voyage to the Moon" (astronomy) and Wells's "The Food of the Gods" (hormones) or "The Story of Davidson's Eyes" (fourth dimension). This seems to be the largest and most popular group.

(2) Novels based upon some scientific discovery or showing the influence of applied science upon society, such as Hergesheimer's "Three Black Pennys" (development of the iron industry).

(3) Stories in which some scientific fact or theory forms the theme, such as Arthur Reeve's detective stories and Rebecca West's "The Return of the Soldier" (Freudianism).

(4) Historical fiction where a distinguished man of science plays an important part, such as Merejkowski's "Romance of Leonardo da Vinci" and Guitry's play of Pasteur. This which would seem to be a fertile field for fiction has apparently been rather neglected.

I should be very much obliged if those who happen to know of good novels or worth while short stories of this sort would give me the titles and authors' names, also if convenient the publisher and the scientific motif.

EDWIN E. SLOSSON

SCIENCE SERVICE,
WASHINGTON

QUOTATIONS

THE WORK OF GENERAL GORGAS

ONE of the last acts of Congress before adjournment was to send to the President a bill to pay a monthly pension of $150 to the widow of General William C. Gorgas, who died in London on July 4, 1920. In 1918 General Gorgas was placed on the retired list, having reached the age of 64. In the two years of life remaining to him his services were in great demand as an expert in sanitation. The Rockefeller Foundation made him director of the yellow fever work of its International Health Board. He visited Guayaquil to see what could be done to clean up that pest-hole. The government of Peru engaged him to carry out a sanitary program in that country. General Gorgas did not live long enough to earn the reward to which he was entitled as a renowned specialist in sanitation. His army pay had increased slowly as he rose from grade to grade. It was not until 1916, two years before he left

the army, that he became a major general. Upon his retired pay, which, of course, ceased with death, he could live comfortably with his family, but only by practicing economy. To gain a modest fortune it was necessary for him to live the strenuous life of scientific investigation in tropical countries, and the time at his disposal was too short. He carried on until he died worn out.

It was an irony of fate that the soldier who had saved an incalculable number of lives by his campaigns against yellow fever and malaria in Havana and in Panama should be struck down at sixty-five while risking his own health to provide for his family after his death. The republic is not ungrateful to its Deweys and Pershings, who are rewarded with special rank and high pay for life for fighting its battles, but may not the charge of failing to recognize the merits of a great soldier-sanitarian like William C. Gorgas be preferred against it? There might be extenuation if the world had not acclaimed him the most efficient plague-fighter of his day. Great Britain sent for him when its own medical men were baffled by the virulence of influenza in the Rand gold mines in 1913, the War Department lending Colonel Gorgas to find means of checking the epidemic, in which he was successful. If he had been an Englishman, Great Britain would have known how to reward as well as to honor him for his invaluable services. Great Britain could only give to him a decoration coveted by its own scientists. France made him a commander of the Legion of Honor. It can not be pleaded for Congress that it has not the power in such a case to reward conspicuous merit and service. If a precedent had been made when General Gorgas retired from the army, there would not now be the spectacle of a belated effort to do something in a small way for the relief of his widow.—New York *Times*.

SCIENTIFIC BOOKS

Plane and Solid Analytic Geometry. By WILLIAM F. OSGOOD, Ph.D., LL.D., and WILLIAM C. GRAUSTEIN, Ph.D. New York, The Macmillan Company, 1921. Pp. xvii + 614.

This book is somewhat larger than the usual American text-book designed for an elementary college course in analytic geometry. The material is so arranged that it is easy to select therefrom suitable subjects for comparatively short courses, and hence the book will be welcomed by those teachers who believe that it is desirable to place in the students' hands books which will enable the most gifted to go beyond what is discussed in class. Emphasis is laid on presenting the subject in the simplest and most concrete form, and on pointing out its relation to physics whenever possible. It may be recalled that Descartes, who is commonly regarded as the founder of analytic geometry, once said in a letter to Mersenne that all his physics was nothing else than geometry.

In view of the fact that the various mathematical theories are so interdependent good text-books for courses in elementary mathematics must cover the same fundamental ideas. There is, however, considerable latitude as regards the mode of presentation, especially as regards illustrative examples and the choice of the problems which the students are expected to solve for the purpose of developing their ability to use the subject. Students can usually prove a large number of theorems which they do not understand until they have applied them in the solutions of different types of problems. The present volume contains a large number of problems selected by men who are well qualified to determine what is most essential for the later progress of the students in pure and applied mathematics.

About 200 pages of the book are devoted to solid analytic geometry. Most of our courses for engineering students are too weak along this line. Many of the standard texts on applied mathematics presuppose a thorough knowledge of the rudiments of solid analytic geometry, and even the ordinary courses in integral calculus and mechanics frequently make greater demands on space conceptions than the student has acquired in the brief course which he followed. The developments found in these last 200 pages are especially to be recommended to students who seek a clear presentation of very useful facts lying just beyond the ordinary elementary course in analytic geometry.

The text-book under review will doubtless remain a standard for many years. It may be too extensive to meet the wants of most institutions for a first course but it will probably be consulted by many teachers who prefer to place briefer treatments in the hands of their students. The high mathematical attainments of its authors are naturally reflected in many details of treatment, and inspire deserved confidence in the accuracy of the statements relating to matters of fundamental importance. The modern tendency towards the insertion of numerous historical notes in elementary text-books on mathematics is not followed here.

It may be added that the authors state in a foot-note on page 177 that a tangent can not be defined as a line meeting the conic in a single point. The opposite view was recently expressed by Professor Cajori in an article published in *School Science and Mathematics*, volume 22, page 463, where the author tries to support an inaccurate statement found on page 163 of the second edition of his "History of Mathematics," 1919. It is here stated that Roberval "broke off from the ancient definition of a tangent as a straight line having only one point in common with a curve." It may also be noted here that some readers might question whether it should be said that a mathematical argument can be convincing without being conclusive, as is implied by the authors in a foot-note appearing on page 180. In view of the extensive literature on Greek algebra the second paragraph of the Introduction is misleading.

G. A. MILLER

UNIVERSITY OF ILLINOIS

SPECIAL ARTICLES

WATER CULTURE EXPERIMENTATION

As a one-salt solution is the simplest possible salt solution, so the simplest growth media that can be devised for plants, provided they need but two elements at a time, should be the proper combination of one-salt solutions. Because green plants require at least seven salt elements, available to and absorbed through the roots, complete nutrient solutions having these elements present together are employed as the media in which the plants are grown. The use of at least three simple salts plus a trace of iron (added as a salt) is required to supply the growth media with the necessary elements.

The writer has recently grown wheat for a period of three months, which included the heading out stage of the plants, in a combination of single salt solutions of KNO_3, $CaSO_4$ and $MgHPO_4$ (each of .01 mol. concentration). The plants grown in these solutions were equal or comparable in their various features of growth, including that of total dry weight, to those of plants grown contemporaneously in complete well-balanced nutrient solutions prepared either with the above named salts or with other salts supplying the same elements.

The salts named appear to be the only three salts that can be used as a combination of three single salt solutions that permit of normal and undiminished growth of wheat. This is the conclusion arrived at from an investigation of culture tests using those salts singly as combinations of one-salt solutions that were outlined as combinations of three-salt solutions (complete nutrient solutions) in the Plan of Cooperative Research on the Salt Requirements of some Agricultural Plants.[1]

Because the mono-basic phosphates given in the plan were found to be too acid for these tests with single salt solution, the diabasic phosphates of calcium and magnesium were substituted for those of the respective mono-basic phosphates. It appears, therefore, that by using the proper salts, wheat plants grow as well with only two nutriment elements present in the media at one time (exclusive of a trace of iron supplied at weekly intervals to all cultures) as they do in complete nutrient solutions.

The set of plants that made best growth, of those sets tested, as combinations of one-salt solutions named, were apportioned among the solutions as follows: four days continuously in KNO_3, one day in $CaSO_4$ and one day in

[1] See Plan of Cooperative Research on the Salt Requirements of Representative Agricultural Plants, prepared for a Special Committee of the Division of Biology and Agriculture of the National Research Council. B. E. Livingston, editor. Baltimore, 1919.

$MgHPO_4$. On the seventh day the plants were transferred back to KNO_3 and the above sequence continued. The plants were rinsed in distilled water with every change of culture from one solution to another. Whether this apportionment of exposure of culture to the several solutions would continue to be the best for the growth of wheat can not be stated until the plants have matured. It appears the best apportionment of exposure of the plants to the different solutions may vary, being not inconsiderably influenced by the aerial growth environment and by the nutrient requirements of the plant at different stages of growth.

Because of its simplicity, the method appears well adapted for investigation of these points as well as for instruction in the principles of plant nutrition. It should aid materially in throwing more light on the causative interrelations of the growth of plants and the composition of the growth media.

W. F. GERICKE

UNIVERSITY OF CALIFORNIA

A NOTE ON THE SPERMS OF VALLISNERIA

AFTER trying for many years to secure favorable fixation of ovules of *Vallisneria spiralis* the writer recently succeeded in getting more fortunate material. Perhaps a few words, by way of preliminary publication, on the method and results may be of interest to workers in this field.

The ovules are borne numerously in the epigynous ovary surrounded by a mucilaginous substance which greatly retards the action of reagents and is but slowly dissolved by water. Cutting the ovary across permits one to squeeze out the contents which in their mass movement break off the ovules and carry them out. Several hours of washing in water are then necessary to free these ovules from their gelatinous matrix. In repeated earlier attempts it was found that all ovules having received pollen tubes completed their fertilization and double fertilization before killing agents penetrated to them. If pistils were killed *in toto* the pollen tubes running down their inner walls in the edge of the gelatin would be well fixed, but the interior ovules were invariably found in poor shape due to the influence of this slime.

Last year the writer modified the method by lowering the temperature of the water used in dissolving the mucilage from the expressed ovary content. The water was cooled by adding small pieces of ice, and the container was set in a larger vessel of iced water. It was hoped in this way to slow down or stop both growth and cyclosis and to hold all parts *in status quo* until killing was possible.

The results were very satisfactory. Sperms were found not only in the tip of pollen tube within the synergid but in all subsequent situations through to the completion of fertilization. Many points regarding the male cells of Vallisneria, previously left obscure through poor fixation, were cleared up by use of this material. A brief statement of findings is given below.

The sperms of *Vallisneria spiralis* maintain their integrity as male cells until the egg is reached. During the journey through the pollen tube they remain joined end to end and pass out of the tip of the tube together. The sperm that later fuses with the egg emerges from the tube as a cell and immediately flattens against the egg membrane. Many preparations showed the male nucleus with its definite mass of cytoplasm and bordering membrane pressed, as a complete cell, against the egg cyst. One would hardly expect to find, in fixed material, stages showing events at the moment the two cells break together, for the union would probably be completed quickly. But the two masses of cytoplasm must intermingle in some degree in fertilization and probably the male cytoplasm partly or wholly enters that of the egg. The male nucleus soon moves to the center and unites with the egg nucleus. There can be no doubt of the morphology of the sperm up to the time of its union with the egg,—they come together as complete cells.

The second sperm loses its cytoplasm soon after it emerges from the pollen tube. Its nucleus is often observed as a spherical body within a strand of protoplasm extending from the egg-apparatus to the polars. Its successive positions suggest that it is carried to the polars by movement of cytoplasm within the embryo-sac. The male nuclei of Vallisneria are never vermiform in the slightest degree nor

is there any suggestion of motility on their part.

ROBERT B. WYLIE

UNIVERSITY OF IOWA

THE AMERICAN MATHEMATICAL SOCIETY

THE twenty-ninth summer meeting of the American Mathematical Society was held at the University of Rochester, Thursday and Friday, September 7-8, 1922, in conjunction with the meeting of the Mathematical Association of America. Special features of the session included visits to the research laboratories of the Eastman Kodak Company and to the buildings of the Bausch and Lomb Optical Company, a chamber concert at the Eastman School of Music, and an automobile drive through the environs of Rochester, arranged by the alumni of the university. A resolution was passed expressing the thanks of the society for the generous hospitality extended.

The attendance included seventy members of the society. The secretary announced the election of ten persons to membership in the society; twenty-one applications for membership were received.

At the meeting of the council, committees were appointed as follows: Professors C. N. Haskins, T. S. Fiske and H. S. White on award of the Bôcher Memorial Prize; Professors D. R. Curtiss, Dunham Jackson and H. H. Mitchell on nomination of officers for 1923.

The medal presented to the society by the Royal Academy of Belgium on the occasion of its one hundred and fiftieth anniversary was exhibited.

A reciprocity agreement was ratified with the London Mathematical Society which grants to members of one society membership in the other at half-rates.

The session of Friday morning was especially marked by a paper read by Professor C. A. Fischer, at the request of the program committee, on "Functions of lines."

The following papers were read at this meeting:

Condition that a tensor be the curl of a vector: L. P. EISENHART.

A new class of topological invariants for two-sided manifolds: S. LEFSCHETZ.

The (1, 2) quaternary correspondence associated with certain space involutions: F. R. SHARPE and V. SNYDER.

On the summability of the double Fourier series: C. N. MOORE.

The theory of sets and the foundation of arithmetic: N. J. LENNES.

Kirkman parades: F. N. COLE.

On the definition of a simple closed surface: R. L. MOORE and J. R. KLINE.

The theory of functions of one Boolean variable: K. SCHMIDT.

Representation of rectilinear motion by the geodesics of a surface: A. MYLLER.

Note on steady fluid motion: S. D. ZELDIN.

Real representatives of analytic complex curves: W. C. GRAUSTEIN.

Extension of Bernstein's theorem to Sturm-Liouville sums: ELIZABETH CARLSON.

A Bohr-Langmuir contact transformation: G. C. EVANS.

An elementary theory of competition: G. C. EVANS.

Groups in which the number of operators in a set of conjugates is equal to the order of the commutator subgroup: G. A. MILLER.

Expansions in terms of solutions of partial differential equations. First paper: Multiple Fourier expansions: C. C. CAMP.

On the minimum of the sum of a definite integral and a function of a point: E. H. CLARKE.

A simple proof of a fundamental lemma concerning the limit of a sum: H. J. ETTLINGER.

Application of Duhamel's theorem to the convergence proof for approximate solutions of differential equations: A. H. COWLING.

Two theorems on multiple integrals: P. FRANKLIN.

An extension of the theorem of Bayes, by the use of a certain limit: E. L. DODD.

Fundamental systems of protomorphic formal modular seminvariants of binary forms: W. L. G. WILLIAMS.

An example in potential theory: O. D. KELLOGG.

On certain systems of differential equations containing a parameter: F. H. MURRAY.

Periodic solutions in the problem of three bodies: F. H. MURRAY.

Functions of lines: C. A. FISCHER.

The expansion of a certain function: I. J. SCHWATT.

The summation of a family of deranged series: I. J. SCHWATT.

The sum of the harmonic series: I. J. SCHWATT.

R. G. D. RICHARDSON,
Secretary

THE AMERICAN CHEMICAL SOCIETY

(Continued)

DIVISION OF INDUSTRIAL AND ENGINEERING CHEMISTRY

W. K. Lewis, *chairman*
E. M. Billings, *secretary*

The control of industrial heating processes: J. A. DOYLE. The paper will be based upon consideration of factors affecting the quality and cost of products subjected to the action of heat in the process of manufacture. Reference will be made to the influence of time as well as temperature in the conduct of such operations and the variable factors that affect the time and rate of heating and cooling. Further reference will be made to factors affecting the selection and use of various forms of fuel or electricity with suitable equipment, and of the necessity of considering the mechanical features incident to heating, cooling and handling, as well as the strictly thermal features incident to the thermodynamics of the problem.

Automatic volumetric analysis—carbon monoxide recorder: GUY B. TAYLOR and HUGH S. TAYLOR. An instrument for automatically making chemical analysis and recording the results is described. The instrument can be adapted to any case where two or more fluids can be mixed in regulated volumes, and the result of the obtained reaction of the fluids recorded by electrical conductivity, temperature rise, etc. Specifically the application of the apparatus to the analysis of flue gas for carbon monoxide is described.

Control devices employed in the high pressure testing of NH_3 catalysts: A. T. LARSON. Flowsheet of one hundred atmospheres experimental synthesis NH_3 plant shown (slide). Need for close regulation of pressure and rate of flow discussed. Various forms of an electromagnetically operated valve are shown. Consists essentially of a valve seat cut in metal block; a valve stem moving in a guide; an adjusting spring for holding stem against seat; and an electromagnet for lifting valve stem off seat. Use of accessories such as gauges, manometers, relays, shown by slides. Flowmeter for gases under high pressure shown. Also compensating device for density balance employed in controlling composition of gas.

The absorption process for the recovery of gasoline from natural gas: J. B. GARNER. The paper consists of (*a*) General description of the absorption process; (*b*) application of process to recovery of gasoline from dry natural gas; (*c*) conditions of operation of a large gasoline plant; (*d*) economies effected in plant operation; and (*e*) physical properties of natural gas gasoline.

The plastometer as an instrument for process control: EUGENE C. BINGHAM, H. D. BRUCE and H. D. WOLBACH. Recent work proves that the *viscosity* of colloidal solutions is not a physical constant as ordinarily measured, but varies with the shearing stress used, so that a certain paint showed a change in viscosity of 10 per cent. when the shearing stress was trebled. It appears that this difficulty is not limited to any one class of colloids, nor are high concentrations of the disperse phase necessary. The difficulty can be overcome by the use of the plastometer. We have, then, two apparently well-defined properties, *viz., yield value* and *mobility.* Colloidal solutions at different concentrations fall into two types—*plastic* and *pseudo-plastic*—between which there seems to be a sharp distinction, dependent upon the character of the structure of the material. Moreover, some colloidal solutions, such as glue and nitro-cellulose, show a definite temperature from plastic solid to true liquid, which is the analogue of the melting point of crystalline substances. Finally the concentration of disperse phase at which the property of plasticity finally disappears appears to be well-defined and measurable and definitely related to the pore space and the volume of the dispersion medium.

A glass pressure gauge: S. KARRER. It is often desirable to measure the pressure of a gas or vapor which will react chemically with the materials out of which ordinary pressure gauges are constructed. An all glass gauge has been developed for this purpose and has been used successfully for several years. The gauge consists essentially of a thin glass diaphragm whose motion due to changes in pressures on it is detected by means of a suitable electrical contact. The unknown gas pressure on one side of the diaphragm is balanced by a known or measurable air pressure on the other side. Equality of these two gas pressures is indicated by the making or breaking of the electrical contact. Gauges having a range of several atmospheres' pressure and a sensitivity of $\frac{1}{10}$ mm. of mercury have been used.

The construction and selection of temperature and pressure instruments for automatic process control: S. S. ANDINSKY. There are three classi-

fications of instruments used in automatic process control: first, indication; second, recording, and third, controlling. Indicating types of instruments are used in determining experimentally and in actual production the exact temperature and pressure specifications to follow to obtain higher quality and maximum production at a minimum cost. Recording types of instruments are used to maintain continuous and permanent records of these readings, which records may then be filed for future reference. Controlling instruments are used to control these temperatures and pressures automatically. In this way there is the assurance of duplicating results. In many cases only by automatic control can certain temperature or pressure specifications be followed exactly.

Some phases of automatic process control: HERBERT A. CLARK. Process control during the initial stages of the development of the process is usually a matter of close observation on the part of the operator and careful hand adjustment to meet conditions as they arise. When the steps become known, the process is standardized and the control is made automatic as far as practicable. If the desired control is merely to keep the temperature constant, some type of thermostat is employed. Where the temperature must be varied in a predetermined way over a certain length of time, an instrument has been devised which automatically varies the temperature of the container at any desired rate, either constant or variable; holds the temperature at any point between certain limits for any desired time; removes the condensation in case of steam-heated apparatus; cools the container at any desired rate at the end of the process; stops the process at any desired point, and signals this fact to the operator.

Hydrogen ion methods as applied to process control: EARL A. KELLER. The increasing use of hydrogen ion measurements in the laboratory has opened a field for such methods in automatic process control. A brief description of an installation is given. Other automatic control methods utilizing electrical measuring apparatus have already been applied successfully, such as the temperature controller in oil-refining processes and in the making of illuminating gas. Electrolytic conductivity equipment has also proven very useful. The value of process control by signal indicating apparatus with manual operation is compared to control that is entirely automatic. A brief description is given of the conductivity equipment used for salinity measurements on battleships. A new method for measuring and controlling turbidity is described, based on the characteristics of a photo-electric cell.

Cost accounting as a factor in the control of chemical processes: CHARLES WADSWORTH, 3D. Once accurate costs are obtained, they must be deftly used. There are many pitfalls for the executive who places blind allegiance in cost figures. Close contact with manufacturing plants is essential, and an understanding of manufacturing problems and manufacturing psychology is *sine qua non.* An intelligent limit can be placed on purchasing, prices and wages. The efficiency of each step in complicated manufacturing processes can be isolated, controlled and made more efficient. The knowledge of whether a product is making money or not enables the executive to control production and sales, especially as to quantities, and to direct emphasis to the most profitable enterprise. As the most accurate indicator of business health, technical men must become acquainted with cost procedure, unless they are willing to remain in positions subordinate to men with business training who understand cost procedure.

The removal of small amounts of CO from gases by passage through heated granular soda lime: ROBERT E. WILSON, C. A. HASSLACHER and E. MASTERSON. The problem of the complete removal of CO from gas streams is of importance in a number of industrial applications, particularly in the purification of hydrogen and nitrogen for the synthesis of ammonia. Several references and patents have mentioned the use of soda lime at high temperatures for the purpose, but practically no quantitative data is offered with regard to the removal of small amounts or the effect of the composition of the soda lime. This paper describes a series of experiments on gas containing 2 per cent. CO in N_2 at temperatures varying from 250° to 550° and using soda limes of varying composition. The results show that soda lime with high caustic soda contents are better than those too low, or than lime alone. The former give substantially complete removal of CO at around 400° C. Small amounts of moisture are helpful in increasing the efficiency but do not appear to be essential. Experiments in the presence of hydrogen are inconclusive because the hydrogen reacted slightly with the I_2O_5 used to determine CO. The fundamental reaction involved is apparently $CO + 2NaOH = Na_2CO_3 + H_2$.

The calculation and comparison of specific rates of corrosion in natural waters: ROBERT E. WILSON. The writer makes use of the fact that corrosion in practically all natural waters at tem-

peratures below 200° F. is substantially independent of the hydrogen ion concentration and is directly proportional to the oxygen concentration. *Specific* rates of corrosion are then calculated in terms of the weight of iron corroded per unit area, per unit time, per unit concentration of oxygen. Units are suggested for the specific rates of corrosion, and formulæ given for calculating these rates from data on (*a*) loss in weight of test pieces and (*b*) drop in oxygen content of water. By thus correcting for the effect of oxygen concentration, etc., it is possible to compare rates of corrosion under different conditions and determine the precise effect of velocity, temperature, etc. It appears that the specific rates of corrosion depend more on velocity than on any other single factor and that the composition of the metal and the hydrogen ion concentration are generally unimportant in under-water corrosion.

A new method of measuring corrosion under water. Investigation of effect of velocity: F. N. SPELLER and V. V. KENDALL. Subaqueous corrosion is nearly proportionate to the concentration of oxygen dissolved in water, which fact is used for measuring the amount of corrosion in the experiments described. Water is passed through a certain length of ¼-inch, ½-inch and ¾-inch commercial steel pipe, uncoated, and the corrosion is measured by the difference in concentration of dissolved oxygen. Time of contact was held constant by varying the length of pipe. Velocities from $\frac{1}{10}$ foot per second to 8 feet per second were obtained. Corrosion-velocity curves are given for each size pipe, for temperatures ranging from 60° to 170° F. Corrosion is found to increase with velocity in all cases, but at a decreasing rate. Rate of corrosion accelerates rapidly with rise in temperature over 90°, velocity and all other conditions being constant. This method of measuring corrosion is applicable to the investigation of the influence of other factors on subaqueous corrosion, such as composition of the metal, character of the water, etc.

The action of sodium silicate when used in soaps: A. S. RICHARDSON. The possible advantages of sodium silicate in soap have been studied under the following headings: Water softening action; detergent action without admixture of soap; and effect on emulsification power of soap. The soap-sparing effect of sodium silicate varies with the conditions of its use, being most pronounced at high temperature and in hard water high in magnesium salts, under which conditions the amount of soap conserved may be more than the chemical equivalent of the sodium silicate used. Sodium silicate has probably no detergent action when used without soap, except in so far as free fatty acid is present in the wash. However, sodium silicate increases the emulsifying power of soap solutions, as shown by a decrease of the surface tension of the soap solution toward a mineral oil.

Counter-current digestion of wood by the soda process: R. T. HASLAM and W. P. RYAN. From a consideration of the law of mass action, the digestion of wood by the soda process seems to offer a field for the application of the counter-current principle. Ungerer, an Austrian chemist, patented the equivalent of such a process in 1872, but no record is found of its commercial application. Recent work has shown that by passing the soda solution in counter-current direction to the wood chips the time required for digestion can be decreased by one third to one half that of the usual batch process, that the yields on small scale equipments are from 2 to 10 per cent. lower, that a better bleaching pulp is obtained and that the alpha (resistant) cellulose content of the pulp is materially increased.

Factors influencing the efficiency of alkali-chlorine cells: W. P. RYAN, C. T. HARDING and R. P. RUSSELL. A study of the effect of effluent flow *vs.* current efficiency at four current densities shows that the efficiency increases rapidly with increased flow, approaching 100 per cent. asymphotically. A plot of current density *vs.* effluent flow at the guaranteed (92 per cent.) efficiency is of especial interest to plants forced to run at varying current densities because of the influence of seasonal changes on power supply. The performance of an Allen Moore cell was studied, and the results show that increasing the effluent flow increased the cathode current efficiency, the voltage and the energy efficiency, although the last decreases as high flows are reached. Increasing current density decreases the efficiency and increases the voltage at the rate of 0.01 volts per amp. per square root. For 92 per cent. current efficiency the salt conversion is very close to 50 per cent. For a given energy efficiency the flow is directly proportional to the current density. For a given current efficiency the flow is proportional to the current density above 75 amp. but falls off rapidly below that.

Physical properties of dental cements: PAUL POETSCHKE.

Filtration formulas: W. K. LEWIS. The formulas hitherto proposed for filtration in chamber

and leaf presses completely fail to apply in the case of sludges which are highly compressible and those to which filter-aids have been added. Careful experimental study of the problem has been made and empirical formulæ developed which are believed to be satisfactory for the problems of engineering design.

Behavior of compressible sludges during filtration: M. P. WOODWARD and W. J. EDMONDS. Careful study has been made of the resistance to flow of liquid through sludges of different types as a function or pressure, pressure gradient and time of filtration. On the basis of the experimental results fundamental differential equations have been derived. One method of solution of these equations has been suggested.

The solvent properties of acetone: R. F. REMLER. The paper takes up the following industrial consideration regarding acetone as a solvent; uniformity of the present grade of acetone from calcium acetate, boiling point and volatility, freezing point, inflammability, dehydrating properties, miscibility with other solvents, use as a coupling or bending agent between immiscible solvents, relative cost per gallon, physiological effects and recovery of vapors. The solubility of acetylene, cellulose acetate and cellulose nitrate, rosin and mineral oils, gums, resins, shellacs, animal and vegetable oils, fats and greases, waxes, asphalts and bitumens are discussed. Mention is also made of acetone in the dry cleaning and leather industry as a constituent of paint, varnish and carbon removers.

Rosin determination in pine products: A. H. VILBRANDT and JAMES R. WITHROW. The determination of rosin in various mixtures, such as pine oils, wood creosotes and kerosene mixtures for materials used as fly chasers or in emulsions for disinfectant purposes is a matter of well-known importance. Results frequently reported by manufacturers and consumers are discordant. The writers have found, however, that the standard methods, with but slight modification for the prevention of emulsions, give results which are accurate easily within ¾ of 1 per cent. and sometimes much more accurate than this.

Some industrial uses of ozone: ERWIN W. FELKEL. The use of ozone in the industries has not been widespread due to two reasons, *viz.*, (1) A satisfactory source has not been obtainable, and (2) on account of the high cost of production. For the past several years ozonizers furnishing a large amount of ozone at a low concentration have been developed, and these machines have demonstrated their durability. The advent of the commercial ozonizer has opened two fields for the industrial application of this gas: (1) in places where a small amount of ozone will accomplish the desired result and (2) in the production of products that sell for a sufficiently high price to justify its use. In the first class we have the bleaching and oxidizing of vegetable drying oils and the drying of paints and varnishes. In the second class is the production of certain aromatic aldehydes and the production of potassium permanganate. Small amounts of ozone at low temperatures bleach an alkali refined linseed oil almost colorless, while if the temperature be raised the major effect is one of oxidation. The drying of varnishes is also an effect of oxidation. This oxidation is antocatalytic and can be greatly hastened by the presence of exceedingly small quantities of ozone in the atmosphere of the drying room. The production of vanillin is a straight chemical reaction in which the ozonide of isoeugenol is made and subsequently reduced. The production of potassium permanganate is accomplished by oxidizing potassium manganate in alkaline solution.

Methanol from methane: RALPH H. MCKEE and STEPHEN P. BURKE. By passing methyl chloride mixed with steam over slaked lime at 375° C. there is obtained a 90 per cent. conversion into methanol (65 per cent.) and methyl ether (25 per cent.). By passing steam and methyl ether over aluminium oxide at 350° C., methyl ether is half converted to methyl alcohol. By reworking the residual methyl ether this conversion can be made complete. The presence of an inert gas, *e. g.*, methane, is not a hindrance to the process. All operations are carried through without pressure and can be arranged to work in a continuous operation. Accordingly we have now available to supplement our failing methanol supplies a process which incompletely chlorinates a high methane natural gas, hydrolyzes the methyl chloride content of same to methanol and methyl ether and reworks the methyl ether to give a final yield of methanol of 90 per cent. of the methyl chloride first made.

The examination of writing inks: F. F. RUPERT. There is need of a system of examination of writing inks which shall proceed on scientific principles and at the same time be related to the needs of the average user of ink, and this paper attempts to provide such a basis. The four qualities of writing inks most desired are color, permanency, stability and non-corrosiveness, and these should be given consideration in approximately equal degree. The relation of composition

of the ink to each of these properties has been studied experimentally, and briefly summarized results are given. The tests now in use by the Bureau of Standards and others are recommended, with modifications, with emphasis on the more practical tests. A system of rating giving equal weight to the four fundamental properties is suggested. Only iron tannate ink is considered in full, but the properties of other inks are discussed briefly.

Non-metallic inclusions: their influence upon ferrite segregation in steel: E. G. MAHIN and H. W. BOTTS. In this paper is presented additional evidence to support the view that non-metallic inclusions in steel are centers of zones of segregation of soluble impurities, and that the segregation of these impurities is the primary cause of ferrite segregation. Giolitti's recent papers are discussed and his theory that only "oxidized" inclusions have any effect upon ferrite segregation is held to be untenable. Oxidation rings and sulfide halos have been studied and discussed in this connection, and photomicrographs are reproduced to illustrate the points at issue. H. M. Howe's conception regarding the mechanism of ferrite genesis is regarded as being correct for all steels except those cooling fairly rapidly from the liquid state.

The determination of various mono-hydric phenols by the phenol reagent of Folin and Denis: CARLETON HENNINGSEN. The phosphotungstic-phosphomolybdic acid reagent of Folin and Denis offers a means for the quantitative determination of a number of mono-hydric phenols in dilute aqueous solutions. The nature of the color produced with these phenols fulfills most of the requirements of a colorimetric method. The intensity of the color produced is dependent upon the concentration of the particular phenol in pure aqueous solutions free from reducing agents. B-naphthol and isoamyl phenol can be used as satisfactory standards for color comparison and offer an advantage over the much used carbolic acid in that they are solids at ordinary temperatures and can be weighed direct with ease.

The acid value of varnishes: MARKS NEIDLE. The correct determination of the acid value of varnishes may be based upon two conditions: (1) The varnish must be of low viscosity so that on shaking with alcohol the distribution of the acid ingredient between the alcohol and the varnish solvent may quickly reach equilibrium; (2) If standard aqueous alkali is used for titrating, after having added alcohol, the final concentration of water in the alcohol layer should not be greater than 30 per cent. or low results will be obtained due to hydrolysis.

Propionic acid and ketones from whey: E. O. WHITTIER and J. M. SHERMAN. The factors affecting the propionic fermentation of lactose have been investigated and conditions determined whereby approximately 2.4 pounds of propionic acid and one pound of acetic acid may be obtained from five pounds of lactose in twelve days' incubation. A mixed culture of *Bact. Acidi Propionici* (d) and *Lactobacillus Casei* incubated at 30° C. for three days is used for the inoculation of the previously sterilized and buffered whey. The mixture of propionate and acetate obtained may be either converted into the free acids and refined or distilled to yield a mixture of acetone, methylethyl ketone and diethyl ketone.

Pittsburgh as an industrial center (historical): J. H. JAMES. The greatest of Pittsburgh's resources is bituminous coal, upon which is built the whole metallurgical development of the district. The glass industry began developing somewhat before the iron, and has had an uninterrupted growth, until to-day its tonnage makes this one of the greatest glass districts of the world. In iron development the stages were pig iron principally for foundry iron at first, puddled iron, crucible steel, Bessemer steel, basic open hearth steel. The fuel first used was charcoal, then beehive coke, then natural gas for basic open hearth steel, and to-day the trend is towards by-product coke, utilization of the coke oven gas in steel manufacture supplemented by producer gas from bituminous coal, offsetting the decline in natural gas. Secondary to the above group are the iron and steel fabrication industries and chemical industries. Most of the chemical industries are merely tributary to the iron and steel.

Governing factors on which paint consistency depends—pigments flocculation one of the most important: HENRY GREEN. The governing factors on which yield value and mobility depend are the viscosity of the vehicle, the pigment-vehicle ratio, the force of flocculation in the pigment-vehicle system and particle size of the pigment. As the force of flocculation in the pigment is the most important of the four factors, it is studied in detail. The paper contains much valuable information pertaining to paint manufacture.

Constants of rosin change after powdering: F. P. VEITCH and W. F. STERLING. Samples of various grades of rosin were powdered and kept in stoppered bottles. Analyses at the start and

after standing one week show a decided decrease in the acid and iodine numbers and a decided increase in the saponification number and melting point. The percentages of unsaponifiable matter remain constant. The results show that rosin should be kept in lump form and powdered immediately before the analysis is to be made in order to prevent changes in its constants.

The effects of treating materials and outdoor exposure upon the water resistance and tensile strength of cotton duck: T. D. JANELL and H. P. HOLMAN. Numerous samples of treated canvas were exposed to the weather for six months under conditions unfavorable to mildew and bacterial decay. Unexposed portions of the same samples after the same length of time showed little or no deterioration. With many of the treatments developed by the Bureau of Chemistry the treated canvas showed very high water-resistance after weathering. By adding certain bituminous materials or mineral pigments to treatments which, when used alone, gave the canvas low water-resistance after exposure, the water-resistance was considerably increased. With all of the treatments free from pigments the treated canvas gave after exposure tensile strengths lower than that of the untreated canvas after exposure. The addition of mineral pigments to certain waterproofing preparations which caused decided weakening of the canvas when exposed to the weather materially reduced such effect in every instance and in some cases the treated fabric after exposure was stronger than the untreated fabric after exposure. The results indicate that the addition of mineral pigments to waterproofing preparations is beneficial since they reduce the weakening effect of solar light and heat without reducing water-resistance.

A new form of precision hydrometer: C. W. FOULK. This hydrometer consists of a glass float moving freely in a glass tube carrying a suitable scale. Between the float and the lower end of the tube a light chain hangs in a catenary curve. The float is ballasted so as to be in approximately submerged floating equilibrium in the liquid to be tested. The final adjustment to exact equilibrium is automatically made by the action of the chain, and this position of the float is then read on the scale. With a properly calibrated instrument density determinations accurate to one unit in the fourth decimal place can be made in a couple of minutes.

Chemical corrosion of iron silicon alloys: A. K. SMALLEY. The desirability of using iron silicon alloys as universal resistant materials for chemical construction and wherever there is a possibility of chemical corrosion has been firmly established. Their manufacture demands the use of the best grades of material, the best foundry practice and careful metallurgical control. Silicon contents should be about 14.5 per cent. If it is lower the acid resistant qualities of the metal will be affected, and if it is higher the strength is lessened and many manufacturing difficulties are encountered. Other specifications are given in the paper.

Furfural resins: CARL S. MINER, JOHN P. TRICKEY and HAROLD J. BROWNLEE.

Distillation of dilute ammonia solutions: G. GALINGAERT. In very dilute solutions ammonia does not follow Henry's law, the volatility being progressively less as dilution increases. In consequence the complete removal of ammonia from ammonia water mixtures is rendered difficult. Careful experimental determinations of the constant of Henry's Law demonstrate that the deviation is due to dissociation and indicate that in extreme dilutions there exists a constant boiling mixture.

Causticization of soda ash: J. HARROP. Experimental determination is reported of the influence of time, temperature and the amount and character of lime used in causticizing dilute soda ash solutions upon the degree of conversion and the rate of settling of the resultant sludge. The significance of the results in design and operation of causticizing plants is indicated.

Decomposition of nitrates: W. K. LEWIS and G. J. GREENFIELD. The thermal decomposition of sodium nitrate into nitrate was studied in order to secure data on the temperature coefficient of the reaction rate constant of a completely homogeneous reaction at elevated temperatures. This data was obtained, and it was furthermore demonstrated that the conversion of nitrate to nitrite is reversible, the reaction equilibrium shifting to the nitrate side as temperature increases. In consequence the reaction rate, after the reaction has progressed to an appreciable extent, is decidedly retarded by the reverse reaction. The decomposition itself is monomolecular, but the character of the reverse reaction has not yet been determined.

Potash from kelp. VIII—Theoretical considerations pertaining to the preparation of potassium chloride from kelp brines: J. W. TURRENTINE and H. G. TANNER. Kelp brine contains, after rectification, potassium and sodium chlo-

rides in the ratio of 20 : 7. These being the principal constituents, the problem of manufacturing potassium chloride therefrom is that of the separation of potassium and sodium chlorides. This is accomplished by alternately evaporating and cooling, the former precipitating the sodium salt, and the latter the potassium salt, advantage being taken of the wide difference in the temperature coefficients of solubility of the two. The cooling is accomplished by boiling in vacuum. The equilibria obtaining and their manipulation for the most convenient operation of the system and the manufacture of potassium chloride of desired purity have been studied from the phase rule point of view. Compositions at the various points of concentration have been determined, and methods of calculating these have been developed and applied to the practical operation of the evaporating and crystallizing processes.

The chemical control of the Mexican cotton boll weevil: LEHMAN JOHNSON. The U. S. D. A. method of dusting cotton plants with calcium arsenate is an effective means of control, but difficult, beyond the intelligence and skill of the average cotton farmer. None the less, in the absence of any easier or more successful method up to this time it deserves the endorsement of the American Chemical Society as an excellent piece of research work and the society's encouragement to simplify, standardize and make more general the application of the method, probably needing a special organization and a large body of trained inspectors and coaches in the method. Comparison is drawn with Mississippi River flood prevention.

DIVISION OF CELLULOSE CHEMISTRY

Harold Hibbert, *Chairman*
G. J. Esselen, Jr., *secretary*

Chemistry of Wood—VI: Results of analysis of heartwood and sapwood of some American species: G. J. RITTER and L. C. FLECK. The comparative chemical composition of heartwood and sapwood of ten American species is given in the paper. The results show that in general the cellulose and the lignin are higher in the sapwood of the conifers, but that these same constants are higher in the heartwood of the deciduous species. The higher yields of cellulose and lignin in the sapwood or in the heartwood of a given species are accompanied by lower yields in extractives.

The acetolysis reaction applied to cellulose isolated from a number of commercial woods: LOUIS E. WISE and WALTER C. RUSSELL. Cellulose was isolated from beech, birch, maple, aspen, oak, pine, balsam, cedar and hemlock by alternate chlorination and sodium sulfite treatments until free from lignin. The cellulose was then converted to "normal cellulose," which was subsequently subjected to acetolysis. In each case appreciable amounts of cellobiose octaacetate were isolated and identified.

Factors influencing the properties of wood cellulose as isolated by the chlorination method: MARK W. BRAY and T. M. ANDREWS. Certain series of pulps made by keeping all cooking conditions as constant as possible except time gave values for alpha, beta and gamma cellulose that did not lie in proper relation to each other. Unless the chlorination conditions are uniform in the preparation of cellulose from these pulps the character of the cellulose is affected. Therefore, a study was undertaken of the conditions which affect the character of the cellulose as expressed in the per cent. alpha, beta and gamma cellulose. It was found that increasing the temperature and time of chlorination (over-chlorination) increases the percentage of non-resistant cellulose in cellulose derived by the Cross and Bevan method. There is very little beta cellulose in pulps or wood before it is chlorinated for the preparation of cellulose, except in decayed material. The action of the organisms of decay in some cases is similar to that of chlorination on the character of cellulose. The copper number of cellulose is a measure of the resistance of cellulose toward 17.5 per cent. sodium hydroxide solution, and also of the amount of over-chlorination. The data indicate that beta and gamma cellulose have the same copper number.

$$\frac{\text{The ratio, copper number of the cellulose}}{\text{per. cent. beta plus gamma cellulose}} = \text{constant.}$$

From the relation of the copper reduction capacity of beta and gamma cellulose, the data indicate that within every three $C_6H_{10}O_5$ complexes there is one aldehyde group.

An improved method for the determination of alpha, beta and gamma cellulose: MARK W. BRAY and T. M. ANDREWS. A volumetric method for the determination of alpha, beta and gamma cellulose based upon the titration of the organic material in Cross and Bevan cellulose has been worked out. The separation of the resistant from the non-resistant cellulose is carried out by treatment with 17.5 per cent. NaOH, filtered by suction or centrifuged and washed. The alpha cellulose is dissolved in 72 per cent. H_2SO_4 made up

to 100 cc. in a granulated flask, an aliquot of which is oxidized with standard $K_2Cr_2O_7$ solution; the excess $K_2Cr_2O_7$ is titrated with ferrous-ammonium sulphate solution. The alkaline filtrate is divided into two equal portions. One portion is acidified with dilute H_2SO_4, causing the beta cellulose to precipitate. An aliquot of the clear solution is oxidized as in the alpha cellulose determination for the estimation of gamma cellulose. The other portion of the alkaline filtrate is used for determining beta plus gamma cellulose. The value for beta cellulose is arrived at by subtracting the result of the gamma cellulose determination from that of the beta and gamma determination. The volumetric method gives a direct means for the estimation of these three constants in determining the character of the cellulose. Filtration and washing difficulties of the gravimetric determination are practically overcome. This method is more accurate and can be carried out much more rapidly than the gravimetric method of Cross and Bevan. Check determinations can be made without repeating the Cross and Bevan determination for preparing cellulose, which procedure is necessary in the gravimetric method.

The gelatinization of lignocelluloses: A. W. SCHORGER. It has been found that lignocelluloses when ground in dilute alkaline solutions attain a high degree of dispersion. The resulting gelatinous product when allowed to dry forms, without pressure, a dense, horny mass having a specific gravity of 1.4-1.5, which is three to five times greater than the apparent specific gravity of the original wood. The peptonizing action of alkali is particularly marked in the case of the hardwoods in comparison with the conifers, the difference being apparently due to the greater hemicellulose content of the former. The cereal straws gelatinize even more readily than woods by the above treatment.

A study of the methoxyl distribution in the products of the soda cook of jack pine (Pinus divaricata): S. S. AIYAR. This paper is a continuation of the work on the distribution of methoxyl in the products of wood distillation previously reported. As the period of cook is lengthened the methoxyl in the pulp gradually falls to a minimum after two hours' cook at maximum pressure. Thereafter the loss of methoxyl is not very appreciable. The liquor in its turn gains the methoxyl corresponding to the loss in the pulp so that all the methoxyl in the wood used is found in the products at the end. The volatile methoxyl derivatives in the liquor reach a maximum in half an hour after attaining maximum pressure, and then their quantity falls. There seems to be a reversal of the equilibrium as the strength of caustic falls and more woody matter is dissolved in the lye. The figures for the lignin and methoxyl contents of the pulp calculated to percentage on the lignin and methoxyl content of wood run parallel. This seems to be another confirmation for the theory that all the methoxyl is associated with the lignin.

Mannose from white spruce cellulose: E. C. SHERRARD. When white spruce wood is hydrolyzed with dilute acid at atmospheric pressure the quantity of cellulose removed corresponds to the quantity of sugar produced. Since no mannan can be isolated from the wood by the usual methods the mannose is probably present as a mannocellulose and not in the adsorbed state. Otherwise, it is difficult to advance an explanation of the removal of a quantity of cellulose corresponding to the sugars produced. The paper directs attention to the presence of mannose as a product of the hydrolysis of white spruce cellulose and also to the fact that this sugar is distributed through the alpha, beta and gamma celluloses. While the mannose is quite easily removed by means of dilute acids a part of it withstands the action of alkali and is even found in cellulose reprecipitated from zinc chloride-hydrochloric or cuprammonium solutions. Mannose has been found in the solutions resulting from the hydrolysis of white spruce cellulose prepared by the Cross and Bevan method, and from soda, sulfate and sulfite processes.

Experimental work on the development of a theory of the protection of wood by preservatives: E. BATEMAN and C. HENNINGSEN. Practical methods of preserving wood against the attack of low forms of life require the injection of some material which either inhibits or kills the attacking organism. A working hypothesis on the protection of wood by preservatives is proposed. It states that wood preservative must possess sufficient solubility in water to produce a solution of lethal concentration. When injected into wood as an oil solution, the active ingredients are distributed in the ratio of their solubilities in water and oil. The paper, which includes new data on the solubilities, solubility coefficient and toxicity of mono-hydric phenols, offers experimental proof of the theory.

Notes on the rosin-sizing of paper. I. The reactions between aluminium sulfate and sodium resinate (rosin size) solutions: ALFRED TINGLE. The experimental results obtained may be sum-

marized as follows: When solutions of these compounds are mixed in stoichiometrical proportions, precipitation of alumina and rosin is complete. When a considerable excess of aluminium sulfate is used the precipitate contains no resinate but consists of free rosin acids with less than their equivalent of free alumina. At certain concentrations all the alumina remains in solution, rosin acids only being precipitated. Rosin acids precipitated in this way ("Rosin B") are not in the same physical condition as when precipitated by mineral acids. Addition of mineral acids to this modification of rosin changes it to the more common form ("Rosin A"). "Rosin B" is probably spongy rosin very thoroughly internenetrated with water.

Notes on the rosin-sizing of paper. II. The process in the beating engine and at the wet end of the paper machine: ALFRED TINGLE. As commonly carried out the reaction in the beater results in the deposition of rosin in the form of "Rosin B" (see preceding paper) on the fibre with less than its equivalent of alumina. Most or all of the remaining free alumina is precipitated as the result of subsequent dilution. That alumina plays no essential part in the sizing is shown by the fact that paper can be successfully sized under such conditions that no alumina can be deposited. Rosin acids can be precipitated even by sulfuric acid in a condition closely resembling "Rosin B" if at the same time another precipitate is formed which will serve to keep the rosin finely divided. In such circumstances the rosin has sizing power. Investigation of the changes in size as paper dries are required.

New methods for measuring the effects of temperature and humidity on the dimensions of paper: HAROLD S. DAVIS. Where paper is used for printing purposes its expansion or contraction between imprints may cause blurring. It is, therefore, of great importance to have a knowledge of the magnitude of the changes in dimension and of the rates at which they take place. A new apparatus is described in which the humidity and temperature are susceptible to easy control and in which the changes in dimensions of different samples of paper may be accurately measured.

Copper numbers of cotton linters: W. F. HENDERSON. A brief description of the source and properties of the material used is given. Samples were treated with various kinds of acids of increasing concentrations, and after washing and drying the copper numbers of the linters were determined. In the cases of strong acids a rapid increase was noted in the copper values, but in the cases of weak acids very little change occurred. Alkalies were used in the same manner, and while the absorptive power of the linters increased, the reducing power remained practically constant. Curves are shown for each series of determination.

Change of viscosity in viscose: W. F. HENDERSON. Linters were treated with increasing concentrations of nitric acid under uniform conditions and afterwards the samples were washed and dried. These products were converted into viscose under exactly similar conditions, and the viscosities of the solutions were measured. A very sudden drop in viscosity was noted as is indicated by a curve which is to be shown.

The determination of the viscosity of cuproammonium solutions: W. O. MITSCHERLING.

The manufacture of standard cellulose: W. O. MITSCHERLING.

Report of committee on the preparation of standard cellulose.

Report of committee on analytical methods. I. Methods of analysis of cotton cellulose.

Report of viscosity committee.

Symposium on the nature of wood cellulose: LOUIS WISE, B. JOHNSON, J. D. RUE, E. C. SHERRARD and others.

Adsorption of salts by cellulose: WILDER D. BANCROFT. Though they merge one into another, we can consider four cases—miscellaneous salts, bases and acids, mordants and substantive dyes. (1) We get a water-ring in filter paper with salts of copper, lead, mercury, etc. We get peptization of cotton by ammoniacal copper oxide, zinc chloride, barium iodide, etc. (2) Barium, strontium, calcium and lead hydroxides may be adsorbed so strongly by filter paper from dilute solutions as to introduce analytic errors. In mercerization caustic soda is adsorbed and changes the structure of the cotton; but no compound is formed. Mineral acids show no appreciable adsorption at moderate concentrations by titration method. (3) Cotton takes up alumina and chromic oxide only from colloidal solutions. In presence of tannin alum is decomposed. Tannin is adsorbed; but must be fixed by antimony, because it is peptized so readily by basic dyes. (4) Sodium and barium salts of substantive dyes are adsorbed as such. Being colloidal solutions the adsorption is increased by electrolytes which decrease the stability; and is decreased when these electrolytes coagulate the dye.

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